RADIO NEWS

MARCH 1944

25c

Canada 30c

RADIO NEWS

"Reg. U. S. Pat. Off."

MARCH • 1944

VOLUME 31, NUMBER 3

CONTENTS

FEATURES

DEPARTMENTS

COVER PHOTO
U. S. ARMY SIGNAL CORPS

Signal Corps walkie-talkie being used to contact headquarters during winter maneuvers.

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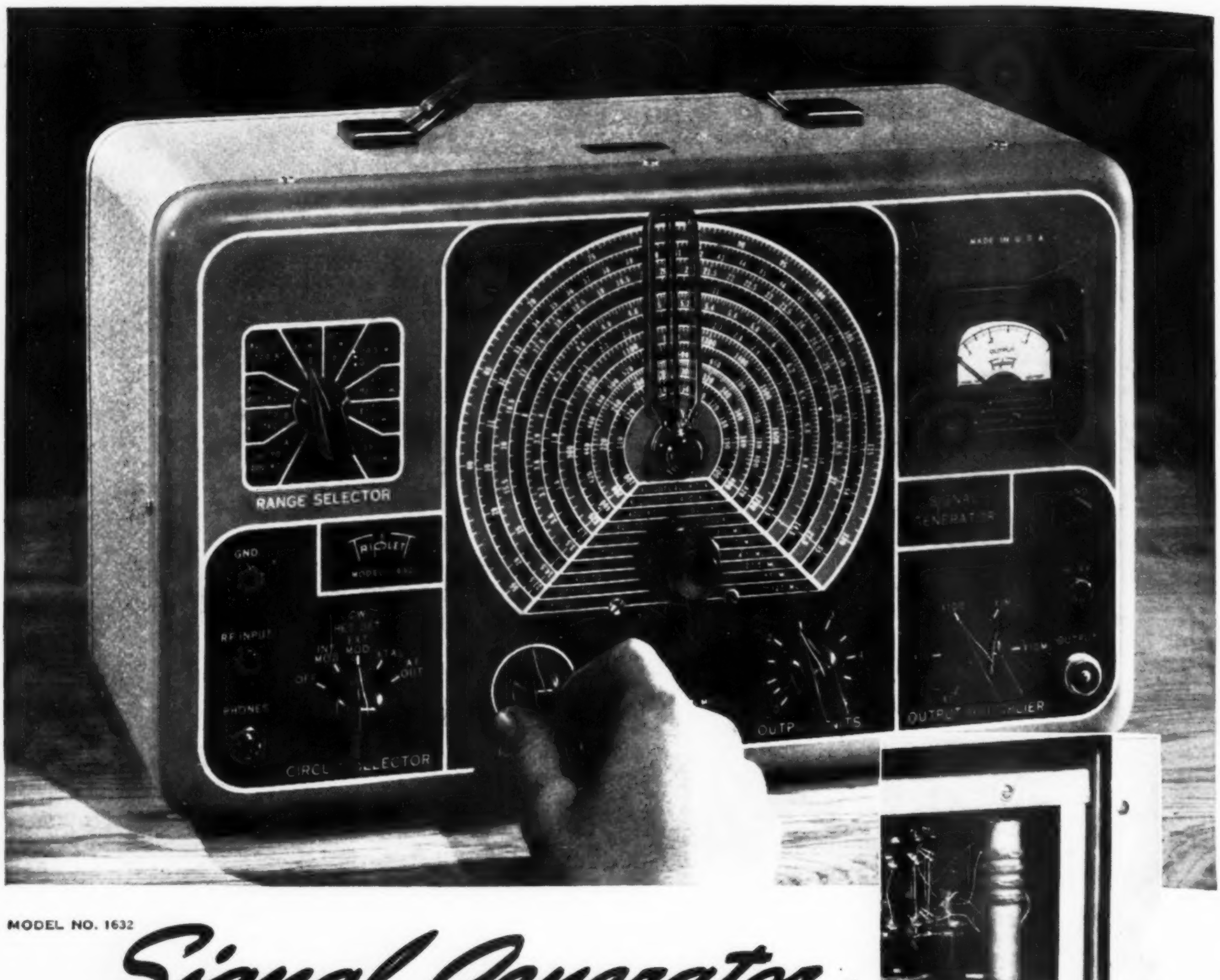
ZIFF-DAVIS PUBLISHING COMPANY

Echophone Model EC-1

(Illustrated) a compact communications receiver with every necessary feature for good reception. Covers from 550 kc. to 30 mc. on three bands. Electrical bandspread on all bands. Beat frequency oscillator. Six tubes. Self-contained speaker. Operates on 115-125 volts AC or DC.

ECHOPHONE RADIO CO., 201 EAST 26th ST., CHICAGO, ILLINOIS



MODEL NO. 1632

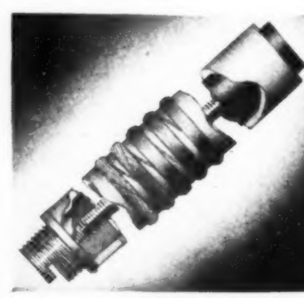
Signal Generator

CONTINUOUS COVERAGE — 100 KC. TO 120 MC. • ALL FREQUENCIES FUNDAMENTALS

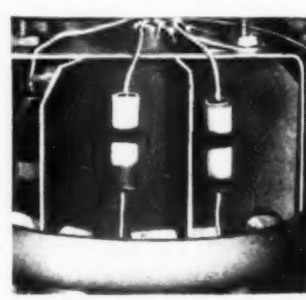
A complete wide-range Signal Generator in keeping with the broader requirements of today's testing. Model 1632 offers accuracy and stability, beyond anything heretofore demanded in the test field, plus the new high frequencies for frequency modulated and television receivers, required for post-war servicing. Top-quality engineering and construction throughout in keeping with the pledge of satisfaction represented by the familiar Triplett trademark.

Of course today's production of this and other models go for war needs, but you will find the complete Triplett line the answer to your problems when you add to your post-war equipment.

• Triple shielding throughout, Steel outer case, steel inner case, plus copper plating.



• All coils permeability tuned. Litz wire wound impregnated against humidity with "high-Q" cement.



• Note sections individually shielded with pure copper. Entire unit encased in aluminum shield.

Triplett

ELECTRICAL INSTRUMENT CO.

STANDARDS ARE SET BY TRIPLETT

BLUFFTON OHIO ★ ★ ★


OFFICIAL PHOTOGRAPH
U. S. ARMY AIR FORCE
A LONG WAY FROM HOME!
● Boring into the sunset, this Mitchell has a rendezvous with danger. Armed to the teeth, and freighted with destruction, she will fight her way in to the "target for tonight" and she will fight her way home again. She and her sisters have a deadly job to do, and radio will help them do it.
Ground stations around the world depend heavily on the HRO receiver for dependable communications with aircraft.
NATIONAL COMPANY, INC.
MALDEN, MASS.

For the Record

BY THE EDITOR

WE ARE firmly convinced that radio can, and will, become a valuable asset to the safety and communications problems of the nation's railroads. Recent news stories indicate a growing interest in this matter on the part of members of Congress, railroad executives and other leaders concerned with the problems of safety and convenience in travel and transportation.

Thoughts of application of radio for this purpose are not new. But the actual application is. Ships and planes are using radio communications for practically all their dispatching and communications. In their case the technical difficulties were relatively simple because interference of terrain and ferrous metals were not generally present. Neither were they troubled with the presence of power lines, signal bridges and other adjacent metallic structures.

But, we are coming into a new era of radio knowledge—a knowledge that has been learned "the hard way." Wars are disastrous and deplorable, but the technical knowledge gained in this war may afford us the opportunity in coming years to actually save as many lives and as much material as the war cost. Our industry's experience in developing two-way radio equipment for tanks and submarines should enable us to lick the majority of the technical problems present in "rail radio."

Many authorities believe that this should be a postwar job—a job that should be delayed because immediate war production goals must be met. But we believe that the problem is an immediate one—one that should receive attention without delay because it is vital that we eleviate as much as possible the loss of material and manpower resulting from the recent epidemic of rail disasters.

We appreciate that rail transportation enjoys the highest safety ratio of any public utility, but we sincerely believe that the use of radio as an additional safety device will enable them to actually increase the safety ratio to a point where it approaches perfection.

WHILE talking to the plant superintendent at our printers the other day—we were told that the February Signal Corps issue of RADIO NEWS was the largest magazine ever printed by them. In fact, as far as we can determine, it is the largest issue ever published in the radio field. Our subscribers received a real bonus with its record-breaking contents of 454 pages.

While we are compelled to use a lighter paper stock—the same as all consumers—we did manage to cover all important branches of the activities of the Signal Corps in a single issue. Now that we've caught our breath—we recall the many trips that were made to gather photographs, to arrange and plan editorial material and to study the vast organization that is the Signal Corps. We found the Officers and other personnel most cooperative in helping to bring to our readers the war-time responsibilities of the Corps and the manufacturers who supply the material they require to "do a job." It is a matter of record that the Signal Corps of today is one of the most efficient organizations of any military branch. We know you will agree!

WE WISH to thank the readers of our Radio-Electronic ENGINEERING and Radio-Electronic MANUFACTURER editions for their many letters of commendation. Plans are being made to even further increase the editorial scope of these inserts. The nation's leading technical authors and industrial leaders will continue to present material of greatest value to the readers of these special editions of RADIO NEWS.

TUBE manufacturing programs for the postwar era indicate that most of the tubes made will be of miniature style. Development and design appear to have progressed to the point where it is entirely practical, from an engineering and economical standpoint, to produce the miniature type tubes for most applications. Engineers say that miniature tube techniques have been so improved that an amazing degree of efficiency can be expected from the most complex multi-element tube. To augment the general adoption of miniature tubes are the new compact dry batteries with shelf life four times greater than prewar units.

RADIO played an important role in our surprise landing on the west coast of Italy on January 22. It was a most stunning and hazardous operation—one that required complete coordination of all forces. Mobile radio units, Handie-talkies, and mine-detectors were in service immediately following the landings. Our troops are depending on us to supply them with ample supplies of communications equipment. They're getting it—the finest and most versatile of any made for military use! O. R.

When the curtain goes up on the approaching post-war era, Federal does not propose to perform sleight-of-hand in producing a startling fantasia in broadcast equipment.

But Federal, which built WABC, the 50 Kilowatt key station of the Columbia Broadcasting System and the most modern transmitter in the country, will produce then, as it will discuss now, up-to-the-minute equipment of even greater power to meet individual needs.

Federal's long experience in building transmitters, in both high frequency and standard broadcast ranges, assures equipment that will measure to the highest standards.

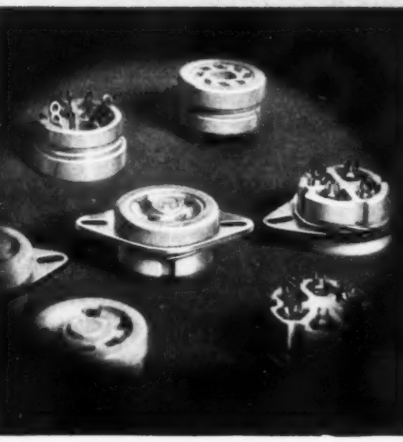
Federal's scientific talent, which includes the world's best technical minds, assures equipment that will embody good engineering practices and proved refinements in design.

Federal invites you to discuss your ideas and its facilities for developing transmitting equipment to your particular requirements.

Most of the leading broadcast stations are equipped with Federal transmitting and rectifying tubes — known for their quality and high standard. Use Federal tubes — built with the ultimate of care and workmanship for satisfactory performance.

Federal Telephone and Radio Corporation

COMMUNICATION PRODUCTS DIVISION Newark, N. J.



Spot Radio News

By LEWIS WINNER
RADIO NEWS Washington Correspondent

Presenting latest information on the Radio Industry.

YEAR END REPORTS FROM INDUSTRY AND BROADCAST STATIONS reveal some mighty interesting facts on the progress achieved on our home and war fronts.

In industry, for instance, plastics played quite a major role. Developments of the year included the impregnating of various types of cloth and paper with plastic resins to produce plastic material that was quite rugged and light in weight. And no expensive tools are necessary to produce the finished products. Interesting plastic parts produced during the year included antenna housings, loud speakers, a variety of components, chassis, and so on. Quartz crystals were also among highlight radio features of the year. An interesting development provided for the application of silver coatings directly to the faces of crystals to prevent frequency changes. This development was of particular assistance in equipment designed for mobile use where the rapid movement was ordinarily responsible for frequency changes of the quartz. The silver coating also permitted the soldering of fine wire, thus facilitating the making of connections.

The transmission of voice over power circuits also rose in popularity during the past year. Developments provided for extremely reliable operation with transmitters having output powers of as low as 3 watts. Transmission over these lines also provided for control of electrical devices, heretofore a project for scores of maintenance engineers.

In broadcasting, transoceanic transmission was intensely active. Over a score of stations were on the air continuously sending out millions of words to all corners of the world. Short-wave listening stations on these shores recorded over a hundred-million words of foreign short-wave broadcasts. Dozens of foreign news reporters reviewed these broadcasts at the rate of over a hundred-thousand words a day. This required translation from as many as fifteen languages.

Frequency modulation was quite active during the year, too. The larger stations maintained operating schedules of up to forty hours weekly. This year that schedule will undoubtedly be doubled in many instances.

Although broadcast stations were required to operate with reduced personnel and limited material for repair, they nevertheless offered service that was favorable with records of station operation in normal times. For the combined service delays amounted to approximately only one-tenth of one per cent throughout the entire year. This is certainly a notable record, and a tribute to the resourcefulness and perseverance of our engineers, technicians and executive personnel.

THE CONTINUED NEED FOR RADIO equipment for the war effort in substantially vast quantities, precludes the possibility of civilian production in 1944. This was revealed by Bond Geddes, RMA general manager, at the recent RMA mid-winter conference in Chicago. He said that even if Germany should collapse, the needs for electronic equipment in the Pacific area are so great that there would be no plant capacity for civilian goods. Officials at the conference said that government contracts for 1944 call for approximately 50% more volume than in 1943.

Mr. Geddes also pointed out that reconversion will come gradually. He said that government control of manpower, materials and prices is inevitable. However, he explained, the radio industry is in a better position to convert than those engaged in heavier industry.

He emphasized that the price range of future receivers constitutes quite a problem, and will require close control. It is entirely possible, he explained, that government pressure will hold down both production and distribution costs to prevent runaway prices.

RMA president Paul V. Galvin explained that the tremendous growth of the industry from a one-billion dollar business in 1942 to a four-billion dollar affair in 1943 should not be taken as a normal business condition. He said that a healthy percentage of this demand will undoubtedly disappear when peace is declared. We must therefore, he said, be ready to adjust ourselves to the many complex problems that will undoubtedly face the industry. He felt certain that although this adjustment problem was a giant one, we will be able to take it in our stride and solve it without too much grief.

Some interesting sidelights on postwar conditions were also presented recently by FCC chairman James L. Fly and FCC engineer E. K. Jett. They implied, for instance, that standard

broadcasting will continue to be used in view of the sixty-million receivers now in homes designed to receive this type of transmission. In addition, they said the primary service is quite good. However, they pointed out, frequency modulation will become an important medium and slowly but surely rise towards great popularity. Their comments on television receivers were quite interesting. As they see it, the many new developments may destroy the usefulness of the television receivers now in service.

They predicted that most of the postwar receivers will provide for standard broadcast, frequency modulation and television reception, and at comparatively moderate prices.

THE SECOND BIRTHDAY of one of the war's outstanding scientific agreements, the British-American Patent Interchange Agreements, was celebrated on January 1st. This agreement has provided for an exchange of patent rights, plans, processes, drawings, designs and technical information between British and American manufacturers on many projects in which radio has been featured. Of course, the agreement which runs for the duration of the war, is confined to manufacturing products essential to it. When the war is over, the patent rights will be returned to their respective owners. Under provisions of the Lend-Lease Act, property interests in the postwar use of all kinds of industrial information are being properly safeguarded.

The agreement provides for the contractor who wishes to use a certain patent, to file his request for this patent through a contracting officer or the technical representative of the service or agency with whom he has made his war contracts. Then a simple requisition is prepared and forwarded to the British representatives.

This agreement was formally signed between the governments of the United Kingdom and Northern Ireland and this country on August 24, 1942. However, it was effectively put into operation on January 1, 1942. Full details on directions and regulations appear in the War Department Procurement regulations, paragraphs 1109-1111 (available from Headquarters, Army Service Forces, War Dept., Washington 25, D. C.) and Navy Procurement directives, paragraphs 14001-14021, inclusive (available from the Office of the Undersecretary of the Navy, Navy Department, Washington 25, D. C.). Copies of the agreement itself are available from the State Department, Washington 25, D. C.

Unfortunately, the products produced as a result of this unusual agreement cannot be described at the present time. However, a host of remarkable radio products have come off the production bench as a result of this agreement . . . projects that we hope to be able to describe soon. In the meanwhile we can say that these projects have contributed materially to the winning of the war. And that's important enough for the present.

ROMMEL'S NEMESIS GOES ON DISPLAY TOUR. WAC Sergeant Mary Jane MacGuire and William J. Halligan, president, Hallicrafters, Inc., Chicago, inspect the display model of

the Army Signal Corps' famous mobile radio unit, the Hallicrafter SCR-299, part of the Signal Corps Production Incentive exhibit now on tour of war plants making Signal Corps equipment.

This complete receiving and broadcasting unit, which carries its own power and measures 29 feet from front bumper to trailer, is credited with establishing and maintaining communications with fast moving Allied troops in the North African campaign and elsewhere.

TUBES HAVE COME BACK TO LIFE AGAIN in Washington . . . at least in one part of Washington . . . the WPB part. For the Radio and Radar Division of WPB has officially approved of a program calling for the production of at least four and a half-million critical types of tubes, in the first quarter of 1944. But the Navy may prevent the entire program from swinging into full effect. Naval officials have stated that they are quite upset by this authorization of WPB for non-military tube production. They say that they are not getting all the tubes they need for their communication equipment. It appears to be the same situation that arose when the WPB released those 576,613 Philips' tubes only to have the Navy step in and claim that they should have first claim on these tubes. Thus far, it appears as if the Navy may take approximately half of this allotment.

The need for tubes by the military is acknowledged, but the civilian requirements are essential, too. It is thus generally believed that most of this allotment, which by the way takes care of but 50% of the industry requirements, will probably be produced and distributed.

The WPB program included particular production emphasis on nine hard-to-get tubes. These are the 12SA7, 12SQ7, 12SK7, 50L6, 35Z5, 35L6, 1H5, 1A7, and the 80. These and other critical types will bear the familiar "MR" stamp identifying them

as having been produced for maintenance, repair and operating supply purposes only. These tubes will not be available for rated orders, and should therefore remain in civilian channels.

This new program is unlike the previous statements of policy. That is, up to now, WPB has implied that one and a half-million tubes a month have been redirected to replacement channels. While every attempt was made to adhere to this policy, distribution problems did arise. However, under the new ruling, which triples the previous policy allotment, the tubes will reach the consumer.

According to present schedules it appears as if a good percentage of these tubes should be appearing in the local shops at about the time this column will appear.

In Canada, M. C. Lowe, the Administrator of Electrical Apparatus, Equipment and Supplies, has indicated that tubes for civilian use will probably not be available until after April 1st. He said that a shortage still exists on many types. However, he hopes that after April 1st a substantial quantity of about 125 different types of commercial tubes may be coming off the production line.

ACKNOWLEDGMENT OF RADIO'S usefulness on trains was made recently by the telephone and telegraph section of the Association of American Railroads maintenance and operations department. Acting in response to accumulated public comment that the installation of radiotelephony might have prevented some of the recent wrecks, this section of the Railroad Association has placed a request for an immediate examination of the public safety possibilities of radio on moving trains, before the RTPB. W. R. G. Baker, chairman of the RTPB, is expected to supply a prompt reply to this requested examination.

Members of the industry have shown keen interest in this proposal. William J. Halligan, Hallicrafters president, said that the radio industry's engineers, if given the opportunity, can make radiotelephone dispatching entirely practical. One solution, he said, might be in the use of carrier-current transmission over telegraph or power lines. He cited that railroad passengers of the future should be able to use radiotelephone systems for regular telephone purposes. Today however, he said, the immediate importance of radio on trains would be to augment telegraph dispatching, block systems and other safety equipment now in use to stamp out rail disasters.

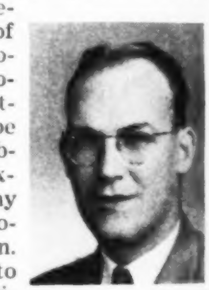
UNUSUAL INTEREST IN RECORDING SYSTEMS using wire, tape and film has prevailed throughout the country during the past few weeks. Apparently, many manufacturers and engineers have become aware of the importance of "packaged voice and music," using, however, other than the disc media. Most of the instruments shown are developments and improvements of old and recently developed techniques; a few employ radically new principles. All of the producers, however, have undertaken their projects with nine major features in mind. These are: (1) playing-time length, (2) compactness of machine and recorded material, (3) cost of equipment, (4) operational cost, (5) simplicity, (6) durability of apparatus and recorded material, (7) maintenance, (8) flexibility and (9) reproduction quality.

Demonstrations have shown that the devices now available do provide many of the necessary features, but none with all the requisites has appeared as yet. Whether the ideal combination will appear soon, is up to not only the engineer, but the chemist and metallurgical expert who provide the tape, film or wire.

Methods used by the systems demonstrated included multi-grooved cellophane or film (using needle embossed and engraved grooves), multichannel film (for photocell operations), emulsion base film (recorded with needle and played back through photocell) and steel wire or tape. Extremely thin discs capable of a multiple of tracks have also been shown.

Some of the systems provide up to eight hours of playing time service, without much attention. Applications of these various systems are indeed numerous. Increased interest will probably prompt not only many other developments, but effective improvements in the apparatus that has been demonstrated.

CECIL L. SLY, vice president and sales manager of the Universal Microphone Co., Inglewood, Cal., is authority for the statement that he is of the opinion that tomorrow's microphones in a post-war world will be marketed to a public eager and anxious to know the why and how of microphone operation. They will want to know the technicalities of the precision instrument and how it works. "This," he avers, "will largely be because so many former ham operators and potential ones, too, are now in communication corps of the Armed Forces. They will not be content to buy something that looks like a microphone. Instead, they will want to see what's cookin', and most manufacturers will increase their number of technical bulletins, blueprints, diagrams and instruction sheets to meet the new trend in consumer buying."

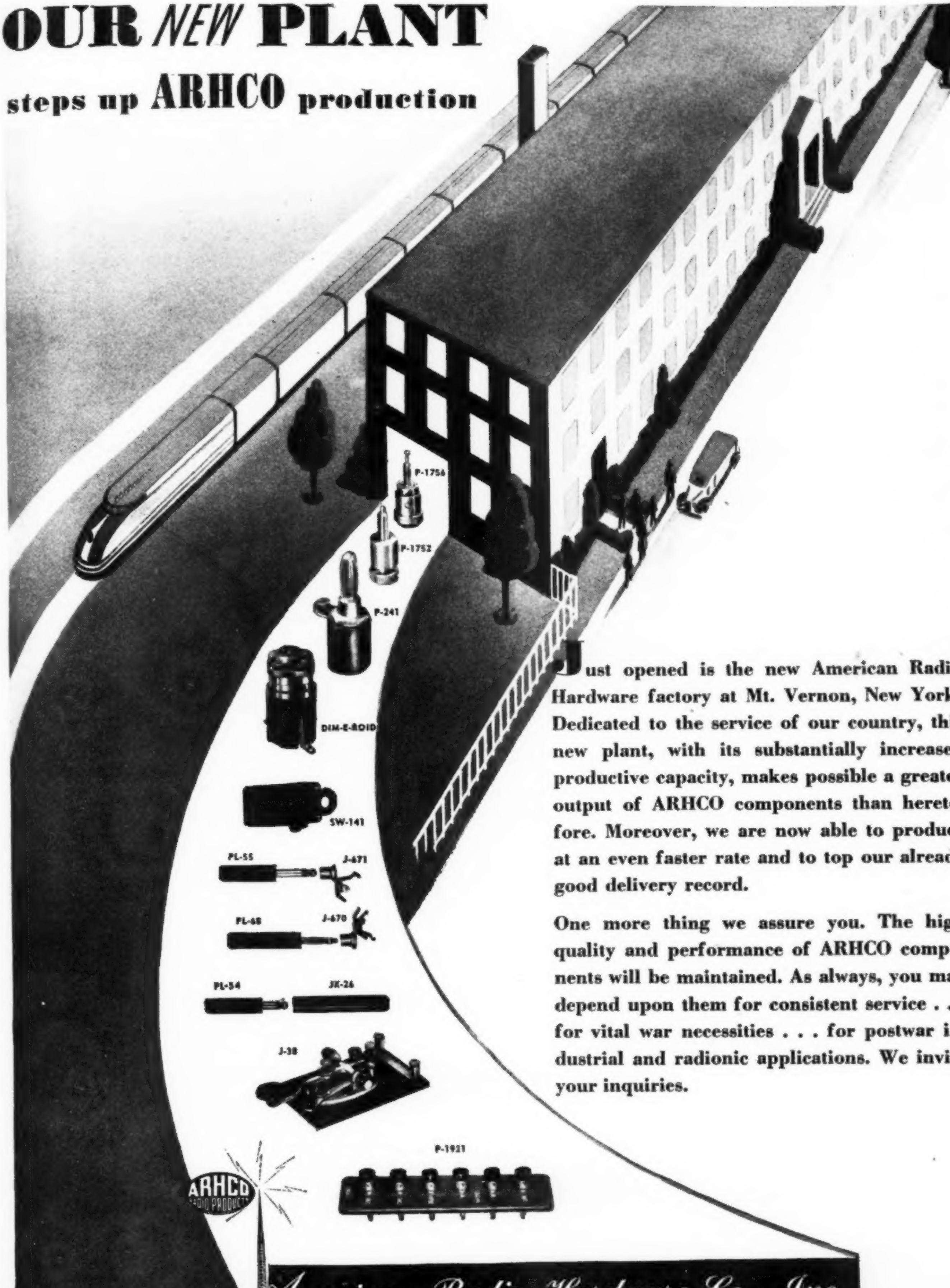


FLYING BLIND BY RADIO became more than a phrase to Aviation Cadet R. D. Seale recently. Three-

(*Continued on page* 96)

OUR *NEW* PLANT

steps up ARHCO production



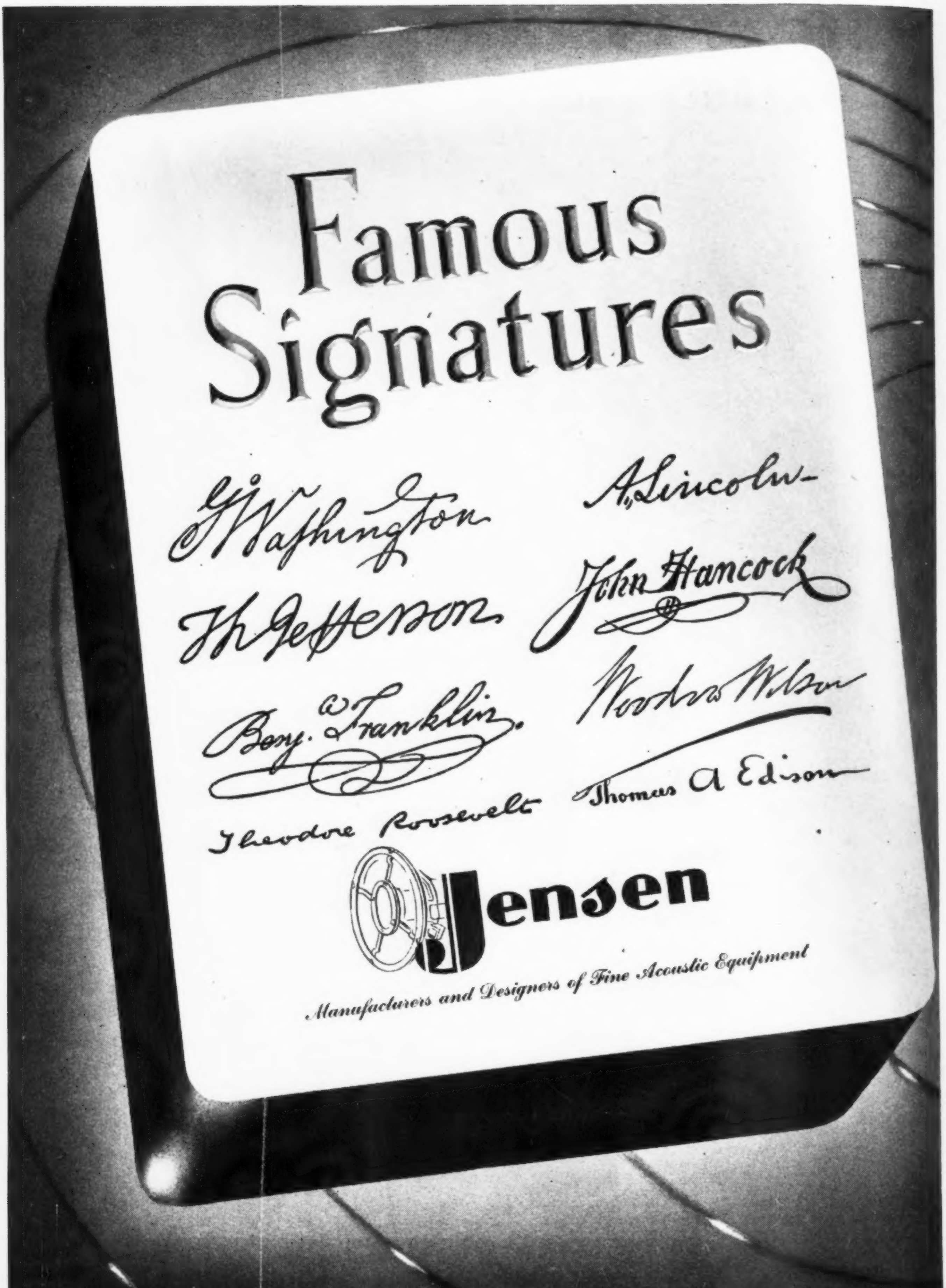
Just opened is the new American Radio Hardware factory at Mt. Vernon, New York. Dedicated to the service of our country, this new plant, with its substantially increased productive capacity, makes possible a greater output of ARHCO components than heretofore. Moreover, we are now able to produce at an even faster rate and to top our already good delivery record.

One more thing we assure you. The high quality and performance of ARHCO components will be maintained. As always, you may depend upon them for consistent service . . . for vital war necessities . . . for postwar industrial and radionic applications. We invite your inquiries.

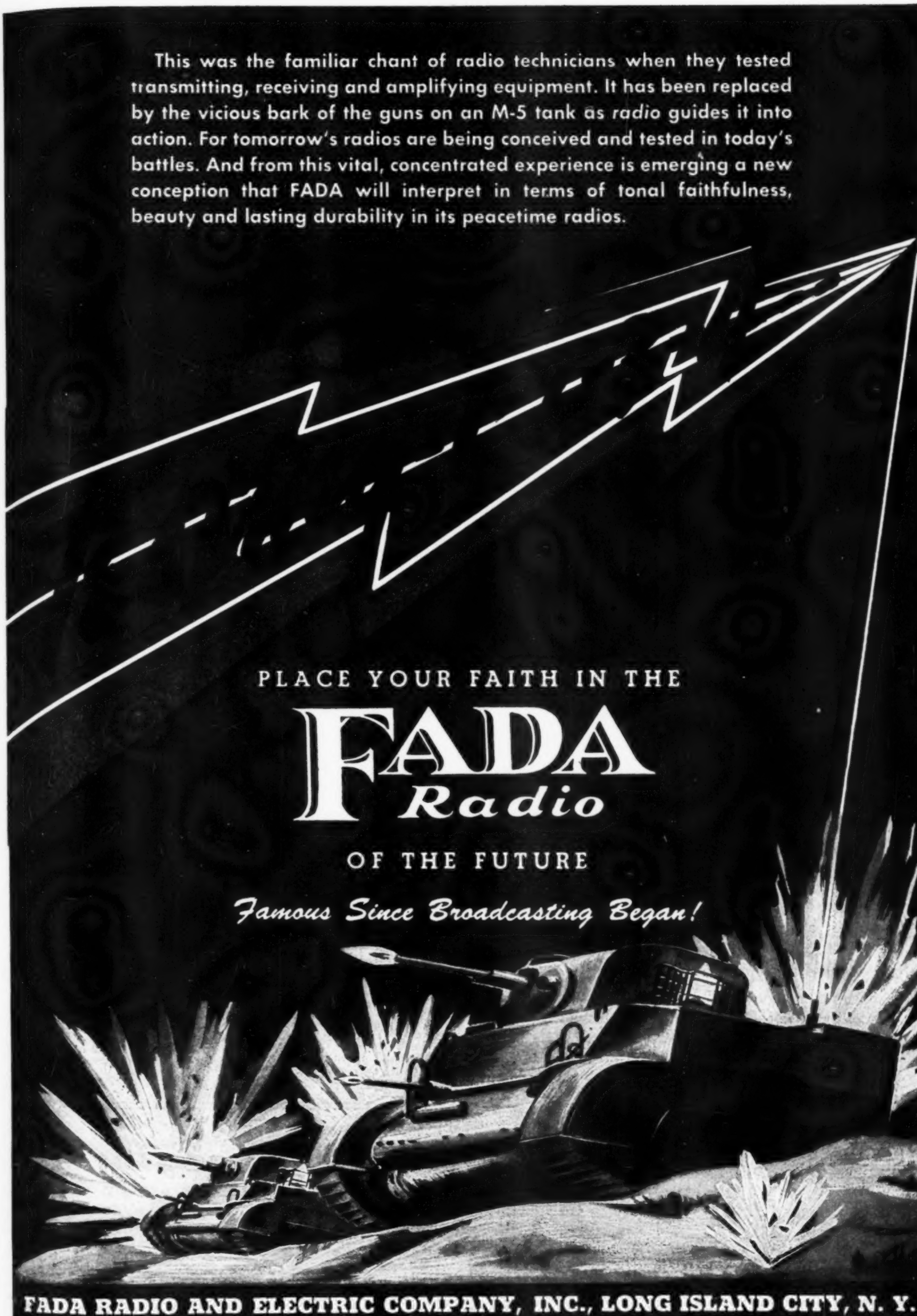
American Radio Hardware Co., Inc.

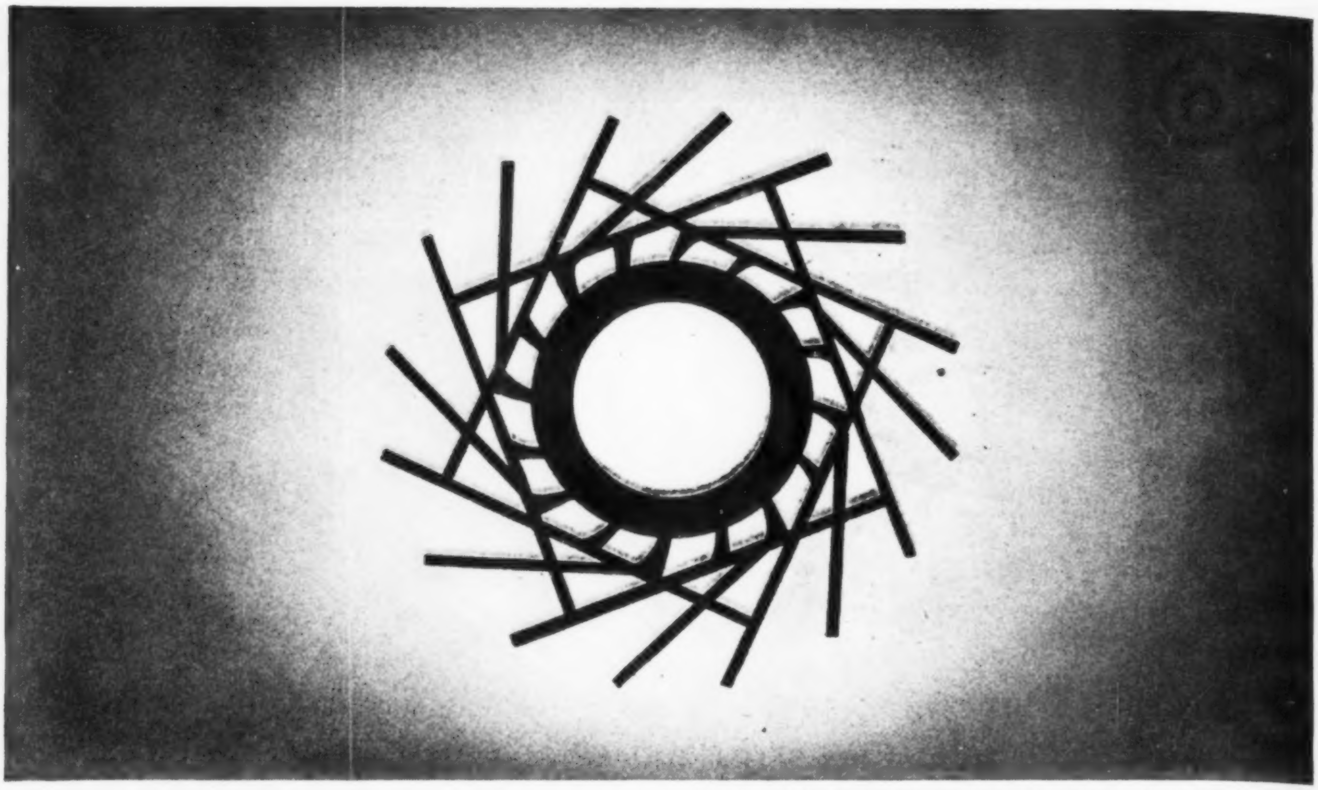
152-4 MacQuesten Parkway South • Mount Vernon, N. Y.

MANUFACTURERS OF SHORT WAVE • TELEVISION • RADIO • SOUND EQUIPMENT



JENSEN RADIO MANUFACTURING COMPANY, 6601 S. LARAMIE AVE., CHICAGO 38, U. S. A.


This was the familiar chant of radio technicians when they tested transmitting, receiving and amplifying equipment. It has been replaced by the vicious bark of the guns on an M-5 tank as *radio* guides it into action. For tomorrow's radios are being conceived and tested in today's battles. And from this vital, concentrated experience is emerging a new conception that FADA will interpret in terms of tonal faithfulness, beauty and lasting durability in its peacetime radios.
PLACE YOUR FAITH IN THE
FADA
Radio
OF THE FUTURE
Famous Since Broadcasting Began!
FADA RADIO AND ELECTRIC COMPANY, INC., LONG ISLAND CITY, N. Y.



American Airlines tangent airport plan for New York City from "Airports and Air Traffic Control" by Glen A. Gilbert, Chief Air Traffic Control Division, CAA.

The Shape of Things to Come . . .

In air transportation especially, the pattern of the future will not be the pattern of the past. No other field holds the prospect of greater advancement nor offers fuller opportunity for sound development.

In things which have made air travel safe and efficient — radio range beacons, markers, communication transmitters and receivers, airport traffic controls—RADIO RECEPTOR, as a pioneer, has contributed its full share of development, and will continue to lead in design and manufacture.

To "the shape of things to come" in aeronautical radio, RADIO RECEPTOR will bring more than 20 years of practical experience. These have been years of successful accomplishment in prewar aviation radio equipment plus outstanding developments born of the present conflict.

Our non-technical booklet, "HIGHWAYS OF THE AIR," explains the importance of radio to aviation. It will be sent to you upon request. Address Desk R.N.-3

"Although an airway may be loosely defined as a designated route for aircraft plying from airdrome to airdrome, it cannot really be said to exist on a practical scale without airways communications, airdrome traffic control, and radio navigational aids. These are the three components furnished, over some 70,000 miles of foreign military airways, by the Army Airways Communications System Wing." —An excerpt from "The Army Airways Communications System," by Lt. W. Fawcett, Jr., Headquarters, AACS.

For Meritorious Service on the Production Front

Radio Receptor Co.

INCORPORATED

251 WEST 19th STREET NEW YORK 11, N. Y.

No. 10 OF A SERIES EXPLAINING THE USES OF ELECTRONIC TUBES IN INDUSTRY

HERE'S an eight-inch billet getting a "massage" that will reduce its square waistline and shape it into a roughly streamlined gun-barrel. The manipulator which feeds the billet under the hammer — back and forth, round and round — requires D-C power for this precision operation. Sturdy G-E sealed ignitrons supply the power.

These steel-jacketed electronic tubes have no moving parts, are quiet in operation; over-all efficiency is high and practically constant over the entire load range. Available in ratings from 20 amp to 200 amp, they convert A-C into D-C economically and reliably.

Rectifiers using the G-E sealed ignitrons for D-C power at 250 volts or more generally will have about the same installed cost, but lower operating costs than a motor generator set. *Their use permits D-C power to be economically applied to "production spots" where D-C motor drives are essential even though you have an A-C power distribution system throughout the plant.*

The steel-jacketed ignitron is only one of a complete line of G-E electronic tubes now working for industry on innumerable jobs and many kinds of machinery. It is the purpose of the G-E electronic tube engineers to aid any manufacturer of electronic devices in the application of tubes. Through its nation-wide distributing system, General Electric is also prepared to supply users of electronic devices with replacement tubes.

"HOW ELECTRONIC TUBES WORK"

THIS BOOKLET will be mailed to you *without charge*. Its 24 pages are interestingly illustrated and written in easily understood language. Shows typical electronic tubes and their applications. Address *Electronics Department, General Electric, Schenectady, N. Y.*

• *Tune in* "The World Today" *and hear the news direct from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday listen to the G-E* "All Girl Orchestra" *at 10 P.M. E.W.T. over NBC.*

G.E. HAS MADE MORE BASIC ELECTRONIC TUBE DEVELOPMENTS THAN ANY OTHER MANUFACTURER

GENERAL ELECTRIC

161-C2

HAMMARLUND RADIO

Official U. S. Navy Photo

EYES AND EARS OF THE NAVY

As our Navy prowls the seas, searching out and destroying the enemy, Hammarlund Radio products help guide our great ships to certain victory. In commercial type marine equipment too, you'll find Hammarlund products are outstanding for their record of service.

THE SIGN OF QUALITY

THE HAMMARLUND MANUFACTURING CO., INC.
460 WEST 34th ST., NEW YORK, N. Y.
Established 1910

Lockheed Electra transport plane.

FUTURE AUTOMATIC AIR TRAFFIC CONTROL DEVICES

By GLEN A. GILBERT
Chief, Air Traffic Control Division, CAA

Postwar program of improvements in air traffic control systems planned by the CAA.

IN PLANNING for the future, decision has to be made as to what constitutes the "foreseeable future." Insofar as the expectations and suggestions set forth in this article are concerned, the year 1950 has been chosen as the end of the planning period. Obviously, as advancement is made, plans should be revised as necessary.

Improvements Now Planned

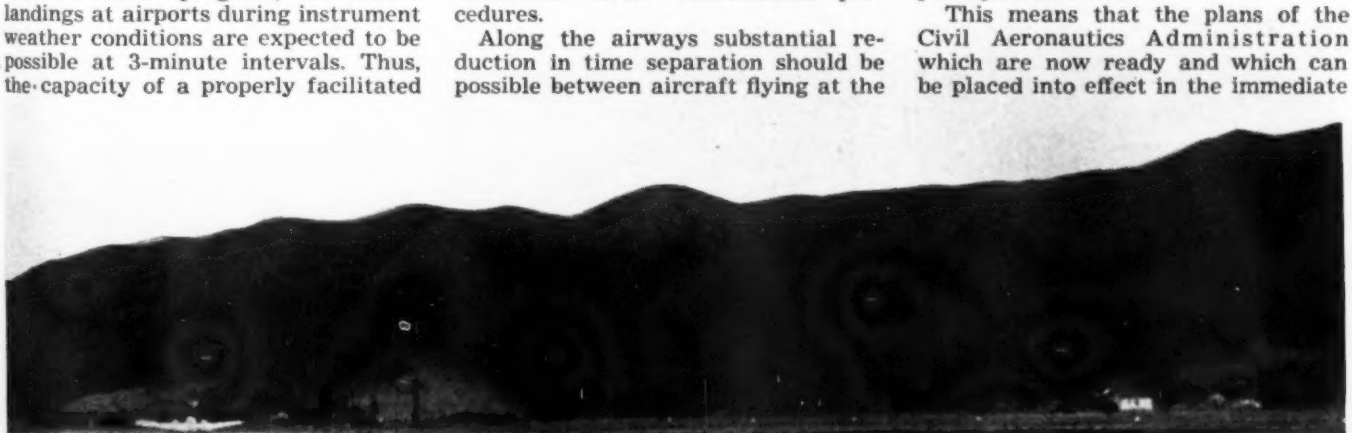
A program of improvements in the present system of air traffic control in the United States has been planned by the Civil Aeronautics Administration. This program is being activated as rapidly as funds are made available inasmuch as the facilities and equipment involved have been developed to a substantial degree and are ready for application with little or no delay.

Included is an improved navigation system using very high-frequency radio ranges and instrument landing systems, the provision of more adequate air-ground and point-to-point communication facilities, the establishment of an automatic system for the handling of flight data and improved control procedures based on the use of the new facilities.

Under this program, successive landings at airports during instrument weather conditions are expected to be possible at 3-minute intervals. Thus, the capacity of a properly facilitated airport will be approximately 20 arrivals and 20 departures or approximately 40 aircraft movements per hour. This compares very favorably with the present situation whereby airports today can handle only approximately 10 aircraft movements per hour during instrument weather conditions under conventional procedures.

Along the airways substantial reduction in time separation should be possible between aircraft flying at the same altitude. Instead of the 15-minute separation between aircraft which applies on some airways today due to insufficient fixes, and a minimum of 10-minute separation on all other airways, it is expected that the improvements planned will make possible a reduction in this separation to perhaps 5 minutes.

This means that the plans of the Civil Aeronautics Administration which are now ready and which can be placed into effect in the immediate



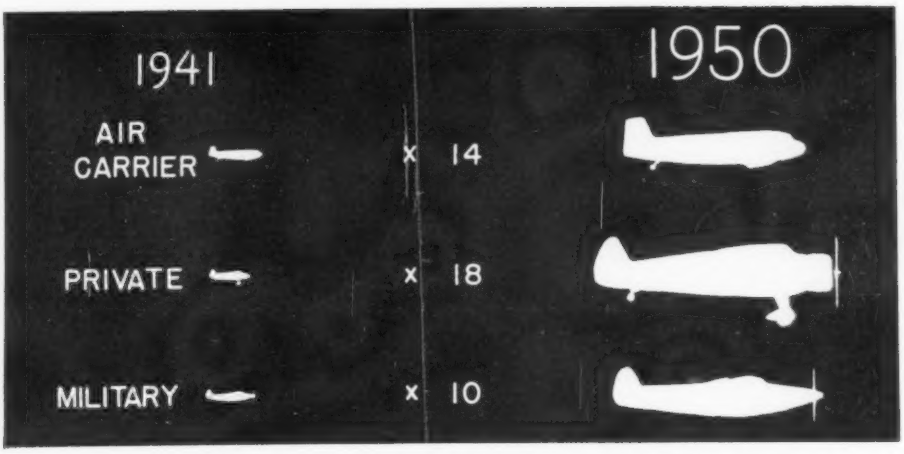


Fig. 1. Estimated increases in air traffic by 1950. For air carrier aircraft 14 times, private aircraft 18 times and for military aircraft 10 times.

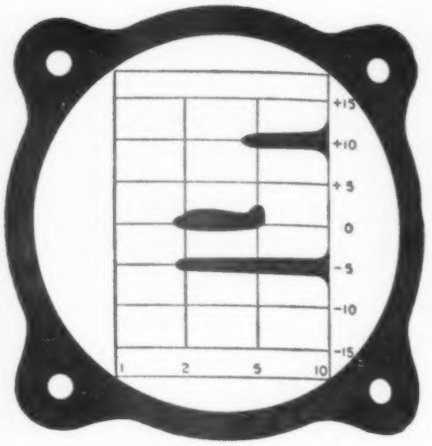


Fig. 3. Vertical separation indicator determines clearance between planes in flight.

future should result in an increase of at least 4 times the present capacity of the United States system of air traffic control.

Air Traffic Development

Will this expansion be sufficient to provide for future needs? Many estimates have been made recently as to the amount of air traffic that will develop after the war. A careful analysis of these estimates and expectations indicates several assumptions which have been generally accepted. These are:

1. Scheduled air passenger traffic by 1950 will increase to approximately ten billion passenger miles, or 5 times the present air passenger traffic.
2. Air cargo by 1950 will amount to at least six hundred million ton miles of freight, express and mail moved by air annually, or 30 times that being transported in commercial air carriers today.
3. A total of approximately five hundred thousand aircraft will be in service by 1950 as compared to approximately thirty thousand before the war.

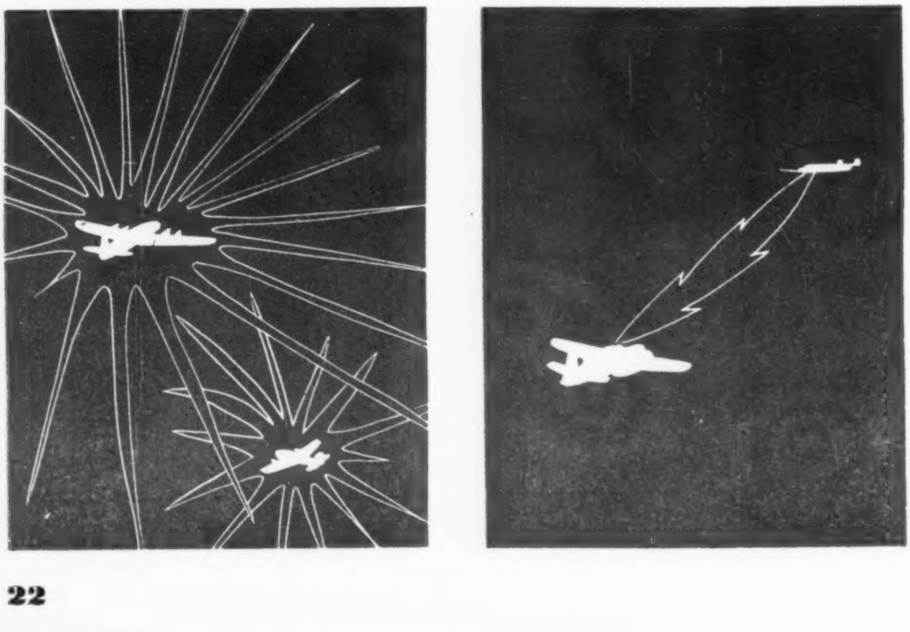
Based on the foregoing, it appears logical to conclude that increases in air traffic (Fig. 1) by 1950 over that existing in 1941 will be approximately 14 times for air carrier aircraft, 18 times for private aircraft and 10 times for military aircraft.

If these expectations become a reality, it is obvious that the improvements now planned will merely be stop-gaps. Further advancement in the field of air traffic control will be required in the years immediately following cessation of hostilities. Such advancement should be aimed at attaining the following ultimate improvement:

1. Elimination of voice as a communication medium for air traffic control.
2. Establishment of facilities and development of procedures which will permit the flow of air traffic in the same volume and with the same frequency during instrument weather conditions as is possible during contact weather conditions.
3. Elimination of the human element in the control of air traffic through the use of automatic devices.

At this writing it appears that the objectives stated above cannot be realized fully in the foreseeable future. Therefore, the plans that are set forth in the remainder of this article are limited to those which are considered within the realm of practicability. The existing air traffic control system and the navigation and communication facilities of the Civil Aeronautics Administration will provide the basis which will permit refinement and improvement to meet the future needs of air traffic control along the lines suggested herein.

Fig. 2. (Left) Symbolizes cooperation between approaching aircraft via radio during peacetime operation and (right) during war when radio silence is essential.



Influence of War Developments

Much has been said about the possibilities of wartime developments revolutionizing or at least radically changing the present system of air traffic control. The war, without question, has accelerated many technical developments. Special progress has been made in the field of electronics. However, application of the various principles and techniques developed has of necessity been directed entirely toward wartime needs.

It appears, therefore, that very few, if any, wartime technical developments will be immediately applicable for the control of air traffic without change to meet peacetime needs. The end of the war will bring improved technical principles and techniques, but their application to peacetime requirements will have to be worked out.

As an example in support of this line of reasoning it might be pointed out that there is a wide-spread opinion that radar devices will greatly change air traffic control in the immediate postwar period. An analysis of the principle of radar indicates that it has its main advantage in detecting the presence of objects which will not "cooperate," such as enemy airplanes and ships during wartime. To obtain such detection it is necessary to provide complicated apparatus involving high cost, substantial weight and special technique for operation.

In the control of peacetime aircraft, however, the situation is entirely the reverse (Fig. 2) in that all aircraft *will* cooperate. In other words, devices can be placed on board peacetime aircraft which will *reveal* their presence. Thus, it becomes possible

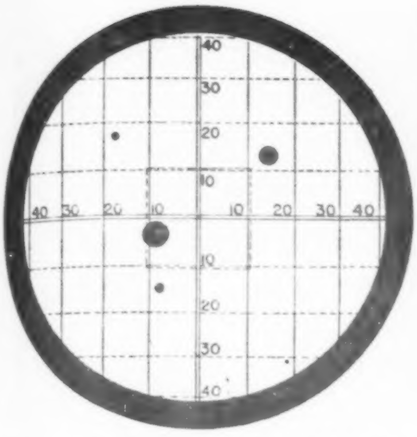


Fig. 4. Horizontal separation indicator. Dots indicate position of other planes.

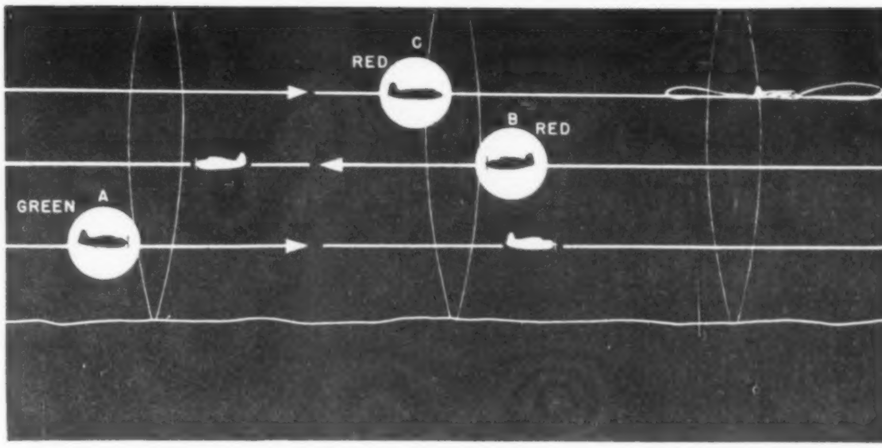


Fig. 6. Block signal system, similar to that of the railroads prevents plane from entering block until cleared, either by plane within changing altitude or leaving area.

to apply a different technique for the detection of aircraft for air traffic control purposes in peacetime which will involve less complex apparatus, less cost, less weight and simpler operation. Certainly some of the improved electronic techniques developed during wartime will be used for air traffic control, but application will be for peacetime requirements, meeting entirely different specifications than those existing under wartime conditions.

In attempting to eliminate or reduce all limitations of air traffic control so as to increase the capacity and raise the efficiency of the system to meet future needs, several devices for installation in aircraft appear to provide possible solutions. These devices will be identified as "collision warning devices," an "automatic position reporter" and a "traffic clearance indicator." The latter two devices may ultimately be compiled to provide a "block signal system."

Collision Warning Device

The ultimate solution for the control of the large number of aircraft anticipated in the future will require that some means be provided which will permit the shifting of a substantial amount of responsibility for the avoidance of collision from ground agencies to the individual pilots of aircraft. In other words, each pilot flying in instrument weather conditions should be able to avoid collision with other aircraft by directly observing indications of the positions of the other aircraft. The means to accomplish this will probably be in the form of a "collision warning device."

Development of one such device, identified as a "vertical separation indicator," was commenced some time prior to the war by the Civil Aeronautics Administration. This device (Fig. 3) will permit a pilot, by reference to an instrument upon the aircraft instrument panel, to determine at a glance the vertical separation between his aircraft and other aircraft within a fixed radius, and will also indicate roughly the horizontal distance of the other aircraft. The pilot will thus be enabled to maintain a specified minimum amount of vertical separation between his aircraft and other aircraft within a certain radius during climb, level flight and descent.

A somewhat different device might be provided as a "horizontal separation indicator." This instrument would be a screen on which various size dots would indicate the relative position of other aircraft (Fig. 4) located within an area ahead of the aircraft concerned and within at least 45° above and below as well as to the right and left. The size of each dot would represent the approximate distance to the indicated aircraft and the location of the dot the angular position of the other aircraft.

These two separator devices together would provide a more complete warning than either device by itself, but the large amount of equipment required would probably destroy the practicability of the combined unit.

Automatic Aircraft Position Reporter

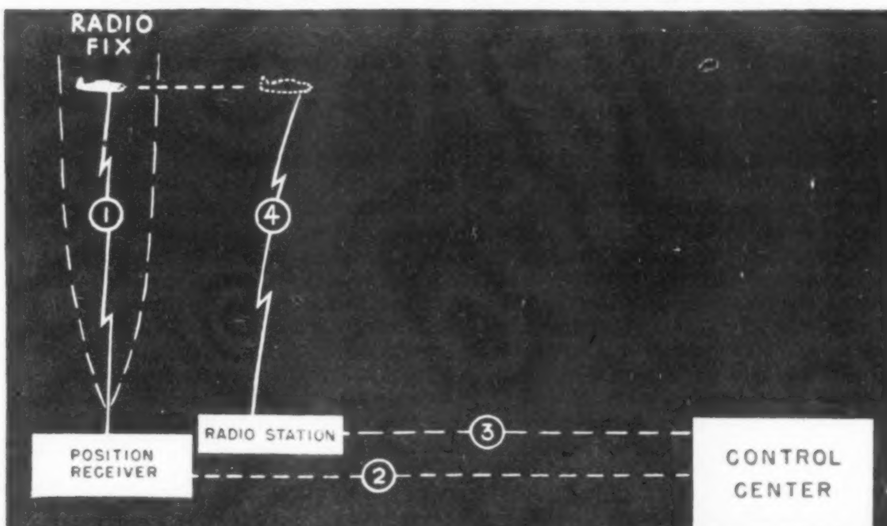
The development of an automatic aircraft position reporter would materially contribute to the reduction of one of the major limitations of the present air traffic control system—the use of voice as a communication medium. This device would permit an aircraft to actuate a reporting mechanism as it passes each fix along the airways in much the same way as a train trips certain signals as it passes predetermined points on its route. This plan, briefly, would involve (Fig. 5) the use of a *vertical pattern transmitter* at each fix, a *receiver in each aircraft* to indicate the entrance of the plane into this pattern, an *aircraft transmitter* continuously set by a controlling altimeter and put into operation under the control of the fix pattern receiver, and a *receiver at the fix* capable of receiving the automatic report signals and relaying them onward to the Airways Traffic Control Center. At the control center the position reports would be fed directly into automatic posting equipment and would appear in proper form and position before the controlling personnel.

Traffic Clearance Indicator

With the establishment of automatic transmission and posting of aircraft position reports and by providing for

(*Continued on page* 86)

Fig. 5. Automatic aircraft position reporter. This device permits aircraft to actuate a reporting mechanism as it passes each fix along the airways.



Radio operator's position alongside of driver in the mobile Illinois crime detection laboratory.

POSTWAR TWO-WAY

By SAMUEL FREEDMAN
Lt. Comdr., USNR

The problems of cost, design, operation, and frequency allocation of postwar two-way radio systems.

IN planning a two-way radio system, the purchaser, invariably a public agency, always has cause to ponder as to what type of equipment facilities to provide. The question of obsolescence is a matter of concern. In every case known, radio equipment becomes obsolete long before it wears out under normal usage.

The equipment of the past and the present becomes the "white elephant" of the future. Such equipment can be expected to be rather inefficient and uneconomic as compared to modern postwar equipment. But that is not all. What will go further to make it obsolete and necessary to scrap is the likelihood of a radical change in channel assignment such as a shift from the ultra-high frequency band to the microwave band. That definitely will involve new equipment and new antenna systems.

Many radio systems were unable to complete their programs when the war came and problems of procurement arose. They contemplate to both complete and expand their program postwar. In some cases, they have been able to buy a few more units that industry still had unsold on its shelves before changing over to all-out war production of electronic equipment. In addition, a limited number of FM sets have been authorized by the War Production Board to be supplied through a police-radio pool. As is always the case, the latest purchaser obtained the latest type of equipment. Thus far the cost has not been lower as time went on but the equipment itself was more modern and much superior in performance. Those who waited until recently have purchased Frequency-Modulated equipment instead of Amplitude-Modulated types.

The postwar 2-way radio set must necessarily be different if for no other reason than the new utilizations to which it is going to be put. This time it will not only be for police, sheriff, fire, public works, fisheries, forestry, public utilities, etc., but it will also include railroads, taxicab fleets, trucking fleets, buses, automobiles and other forms of transportation.

Immediately the question will arise: "How about channel space and the

Radio operator's position at the control panels of the Buffalo Police Department radio station.

RADIO SYSTEMS . . .

FCC." Many will claim that the FCC will not grant licenses for such widespread utilization. That would be as wrong as to say that they are opposed to radio development and progress. A study of frequency allocation in the past conclusively indicates that the Federal Communications Commission has done very well in spreading the advantages of radio communication to as many as possible. It tried to make it available for as many utilizations as could be accommodated on frequencies heretofore considered available and feasible.

The Federal Communications Commission, as set up by legislation and as it actually functions, is here to regulate and facilitate the use of radio for the benefit of the people. It gives preference to agencies or groups who need to use it for the protection of life and property in the case of 2-way radio on the ultra-high frequency band. It has not been able to go as far as it would have had to go in order to accommodate all applicants. For example, it has not been thus far possible to provide channels for railroads and other forms of commercial or private transportation on land.

In the final analysis, the Federal Communications Commission must control licensing to the extent that a license has to depend on which frequency is desired and how many want to use such a frequency. If the applicant can show that he is asking for a frequency that is an empty part of the radio-frequency spectrum, particularly in a region hitherto considered useless for communication, the situation becomes different. For example, an applicant to use a small spot in the microwave band and in a position to prove that he can make equipment work satisfactorily down there has an excellent chance to obtain authorization. This authorization can then be not only for a new channel being utilized for the first time, but it also can be for utilizations never undertaken before.

This means that in order to use 2-way radio for railroads and commercial users, it is necessary that equipment function on channels other than those heretofore allocated for any other utilization. Specifically this means channels exceeding 300 megacycles and preferably those in excess of 1000 megacycles. Such equipment will definitely be available postwar and would be available tomorrow if the war ended. For example, the writer is in a position to state that an application for patent at this moment is pending which proposes to use microwave communication 2-way for railroads and all forms of transportation on frequencies well into the microwave band. This invention utilizes simple, compact and inexpensive unattended automatic relay stations

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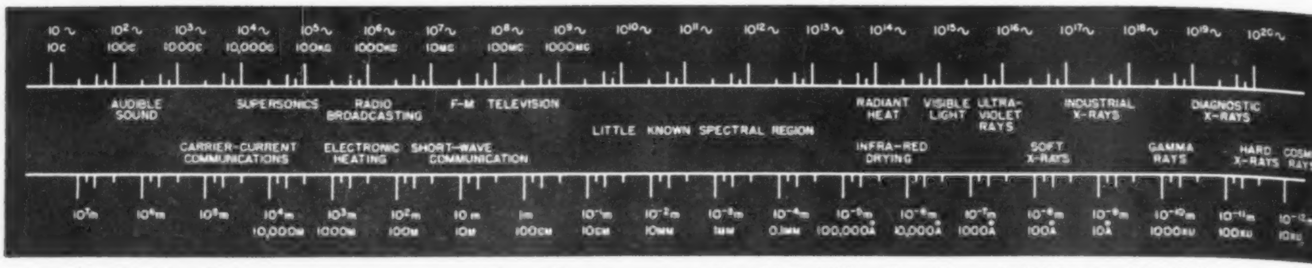


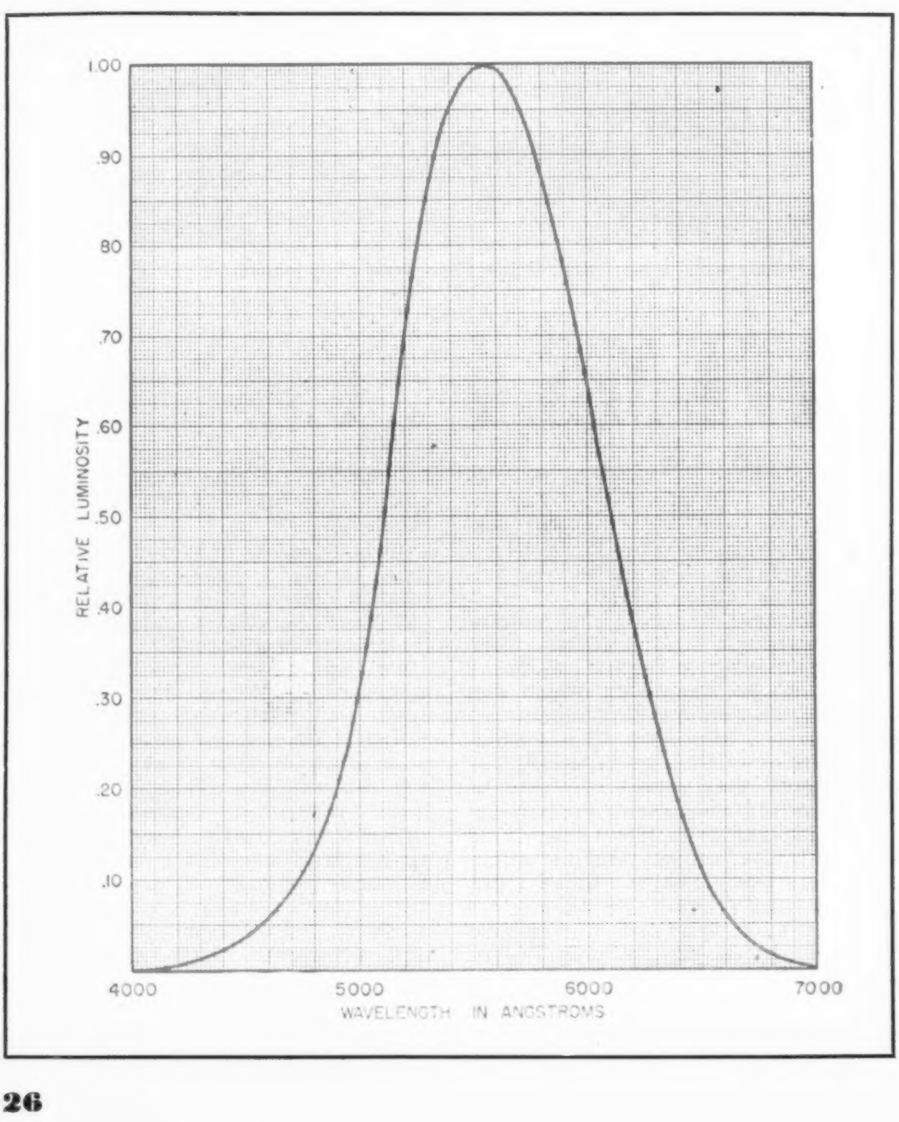
Fig. 1. The electro-magnetic spectrum covering a frequency range from 10 to 10^{20} cycles. The unit XU is equal to 10^{-11} cm.

ELECTRO-OPTICS

By ALBERT A. SHURKUS

Covering the fundamentals of optical and electronic design engineering, including the basic theory of many of our visual test instruments.

Fig. 2. Visibility curve of a normal human eye showing the point of greatest sensitivity.



DURING the past twenty years a new science has been in the process of development, although only during the past five has it made any significant progress. This new science, called "Opti-onics"[1] by some, has been referred to in the past as optical electronics or "electro-optics". It is the combination of the two older, and now well-established, sciences of optics and electronics. The combination, although dealing with problems which are, in the main, optical, places greater stress upon electronics.

One need not look far to find these "electro-optical" instruments rapidly replacing visual instruments like spectrophotometers, colorimeters, photometers, fluorimeters, and many others formerly considered the concern of the optical engineer. The rapid acceptance of these new instruments is attributable not only to the ease with which they lend themselves to measurements involving color and light, but also to their speed and lack of fatigue. It is certain, too, that these instruments will meet with even wider acceptance in the future and will enter many new phases of our daily life. For example, photoelectric spectrophotometers will specify the colors of the clothes we wear and the paints we use, photoelectric fluorimeters will measure the potency of some of the vitamins we consume, and photoelectric colorimeters will guard those of us who must work in potentially toxic atmospheres.

Optics is that portion of physics which treats light, its genesis and propagation together with the effects it suffers and produces. This is indeed

[1] *Copyrighted trademark of the Bell & Howell Company, Chicago.*

a broad field and, hence, it is usual to divide it into the sub-classifications of geometrical, physical, and physiological optics. Geometrical optics is concerned with the design of lenses and lens systems; physical optics treats the production of light and the effects it suffers and produces passing through physical media; physiological optics deals with the effects of light upon the visual mechanism. Of course, it is far beyond the scope of this article to treat any of these branches with any pretext of completeness. All that can be hoped for is that the reader might be given some insight of the science in the most general terms.

Light

Physicists are now satisfied that the excitation of elementary particles of energy like molecules, atoms, and electrons will cause the emission of radiant energy. This excitation may come about in a number of ways, among which are the collision of atoms with rapidly-moving charged particles and the heating of a metal which presents high resistance to the passage of an electric current. This radiant energy may exhibit itself in various forms, the gamut of which we have come to call the electromagnetic spectrum. A pictorial representation of this electromagnetic spectrum is shown in Fig. 1. As can be seen, this radiant energy may be evidenced among other things, as radio waves, infrared rays, light, ultraviolet rays, and X-rays.

Insofar as both are wave motions emanating from excited particles of energy, light is similar to radio waves. Light, however, is most strictly defined as that radiant energy capable of evoking a visual stimulus, although the physicist has now generally fallen into the habit of including both the near ultraviolet (i. e., near to the visible region of the electromagnetic spectrum) and the near infrared. But while radio waves are produced by electric charges that oscillate in a resonant circuit, light waves are produced by electrons oscillating in

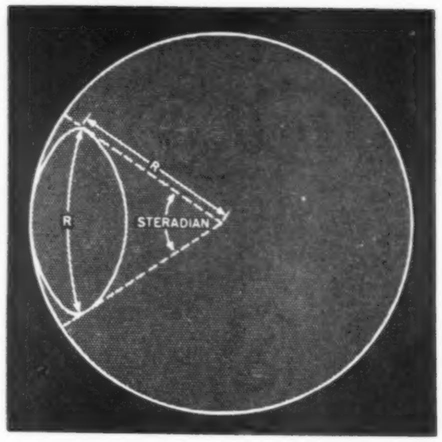


Fig. 4. Method of determining the lumen unit.

the atom itself. Because of the rapidity of the oscillations producing light, its wavelength is extremely short. The wavelength of light is measured in angstrom units, the angstrom being 10^{-8} centimeters,[2] and is usually symbolized by Å. The visible spectrum extends from 4000 to 7000 A. for the average observer; some eyes, however, can see from 3800 to 7600 A.

The retina, it must be pointed out, is not equally responsive to all wavelengths. The ability of the eye to respond to radiant energy varies throughout the visible spectrum and the visibility curve of a normal human eye is shown in Fig. 2. As the curve indicates, the normal eye is most sensitive to radiant energy of 5550 A. This visibility function must always be remembered whenever a photoelectric system is used to replace the eye for measurements of color or light intensity.

The Spectrum

The light emitted by a material subjected to some form of excitement can be dispersed, i. e., separated into its various component wavelengths, by a prism or a grating. It was indeed a milestone in optical history when, in the 17th century, Sir Isaac Newton discovered that a prism could disperse white light. The diffraction grating is a system of very closely spaced equidistant and parallel lines ruled upon a polished surface.

When dispersed, light may be found to have a spectrum consisting of lines, bands, or to be continuous, depending upon the source of radiation (Fig. 3). A line spectrum, as the name implies, consists of isolated lines of various frequencies, and is produced by an element in its gaseous state. It is that spectrum obtained, for example, when an arc is struck between iron or copper electrodes. The arc creates a temperature high enough to vaporize the tips of the metallic electrodes, the vapor being, in turn, excited sufficiently to emit light of characteristic frequencies. The line spectrum is that usually employed for quantitative and qualitative spectrographic analysis since each element possesses its own unique set of characteristic lines. A band spectrum is characteristic of molecules and is produced by a com-

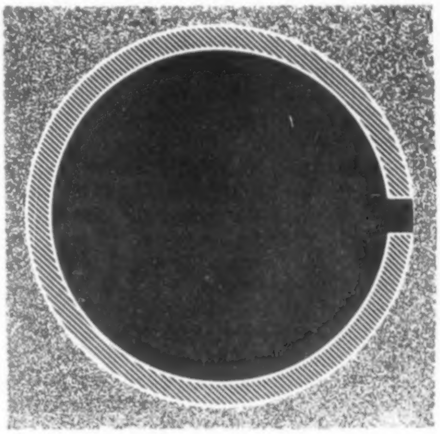
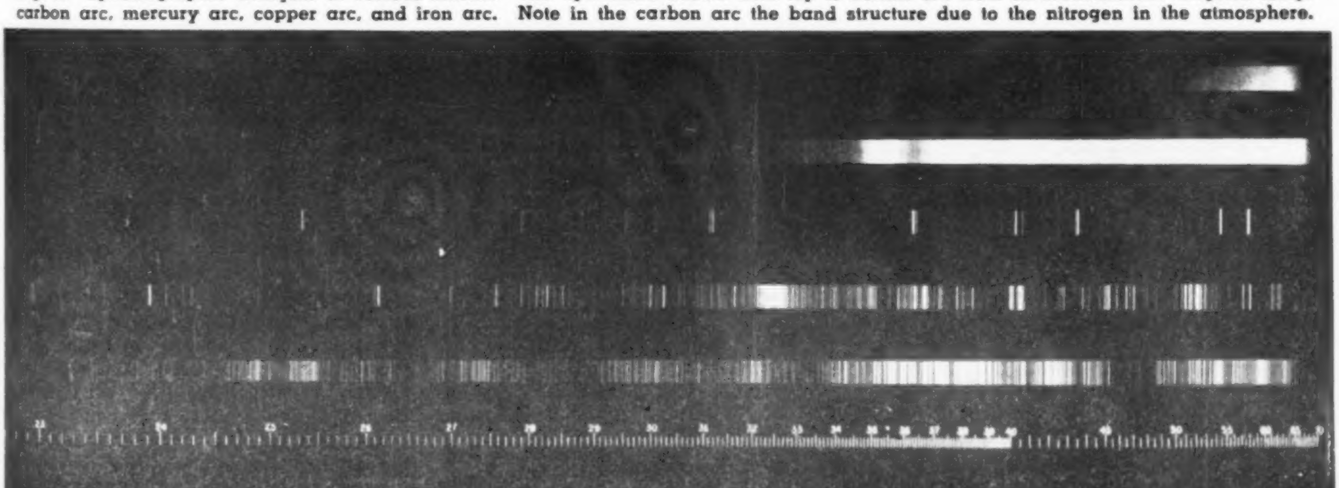


Fig. 5. Cavity to obtain truly black condition.

pound in its gaseous state. A continuous spectrum is characteristic of solids that have been heated to incandescence, like a tungsten lamp filament. This type of spectrum has, apparently, no structure and can be considered as possessing radiation of all frequencies.

[2] *1-inch = 2.54 centimeters, ∴ 1 A = 0.000000004"*

Fig. 3. Spectrographic analysis of various metals. The spectrums shown from top to bottom are from an incandescent tungsten lamp, carbon arc, mercury arc, copper arc, and iron arc. Note in the carbon arc the band structure due to the nitrogen in the atmosphere.



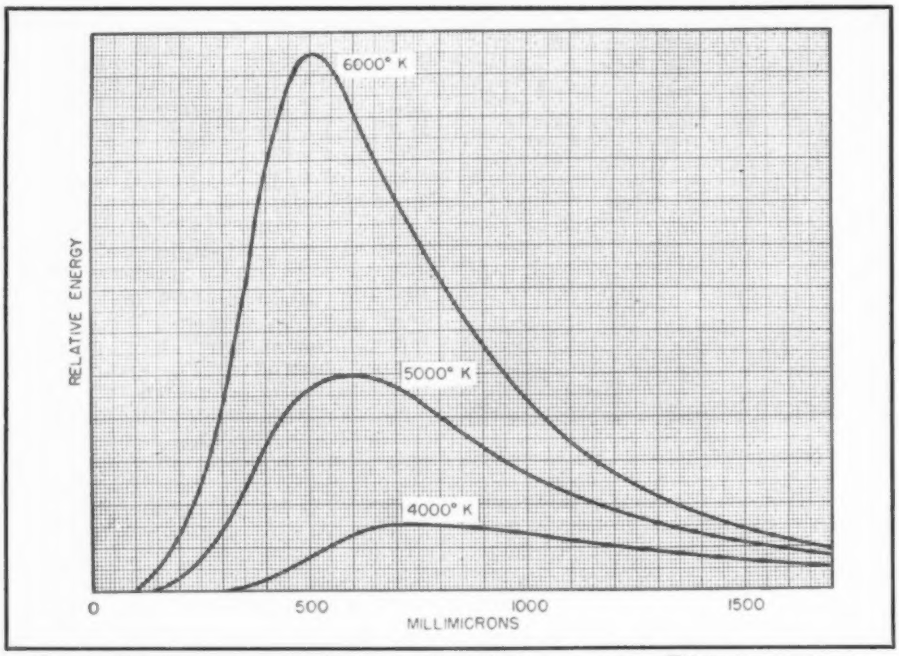


Fig. 6. Relative energy distribution for black bodies at various Kelvin temperatures.

Monochromatic is the term that is applied to radiation of a single frequency or a very narrow band of frequencies, and monochromatic light is obtained by the isolation of a single-radiation frequency or narrow band of frequencies from any of the spectrum types listed above. It is, of course, most easily obtained by the isolation of a single line from a line spectrum. If the line spectrum is of a simple structure, like that of mercury, the isolation can be achieved through use of filters. If, on the other hand, the spectrum is complex, like that of iron, or continuous, then an optical instrument employing the dispersion produced by either a prism or a diffraction grating must be used. Such an instrument is the wavelength spectrometer.

A band of frequencies (or wavelengths) can be isolated through use of colored filters placed before an incandescent source. The narrowness of the isolated band is dependent upon the filters chosen for the task. In general, dyed gelatine filters are able to pass more energy in a narrow band than can colored glass filters. Glass filters, however, are preferable for this work because they are less apt to change their characteristics with age and are less liable to be adversely affected by heat.

Photometric Units[3]

The original standard of light intensity used was the English Standard Candle defined as a spermaceti candle ⅞" in diameter made to burn at a rate of 120 grains per hour with a flame height of 45 millimeters. Spermaceti is a waxy solid separated from the oil of the sperm whale. It became apparent with use, however, that a standard such as this was difficult to maintain constantly and to duplicate. Following the appearance of the carbon filament, therefore, the national standardizing laboratories of France, Great Britain, and the United States concurred upon an international agreement in 1909 basing the definition of the international candle upon a group of well aged and carefully operated carbon-filament lamps. In this country, the candle is a specified fraction of the average intensity of a group of 45 carbon-filament lamps preserved at the National Bureau of Standards. Since the candle is now the easiest photometric unit to maintain, all other photometric quantities are defined with respect to it.

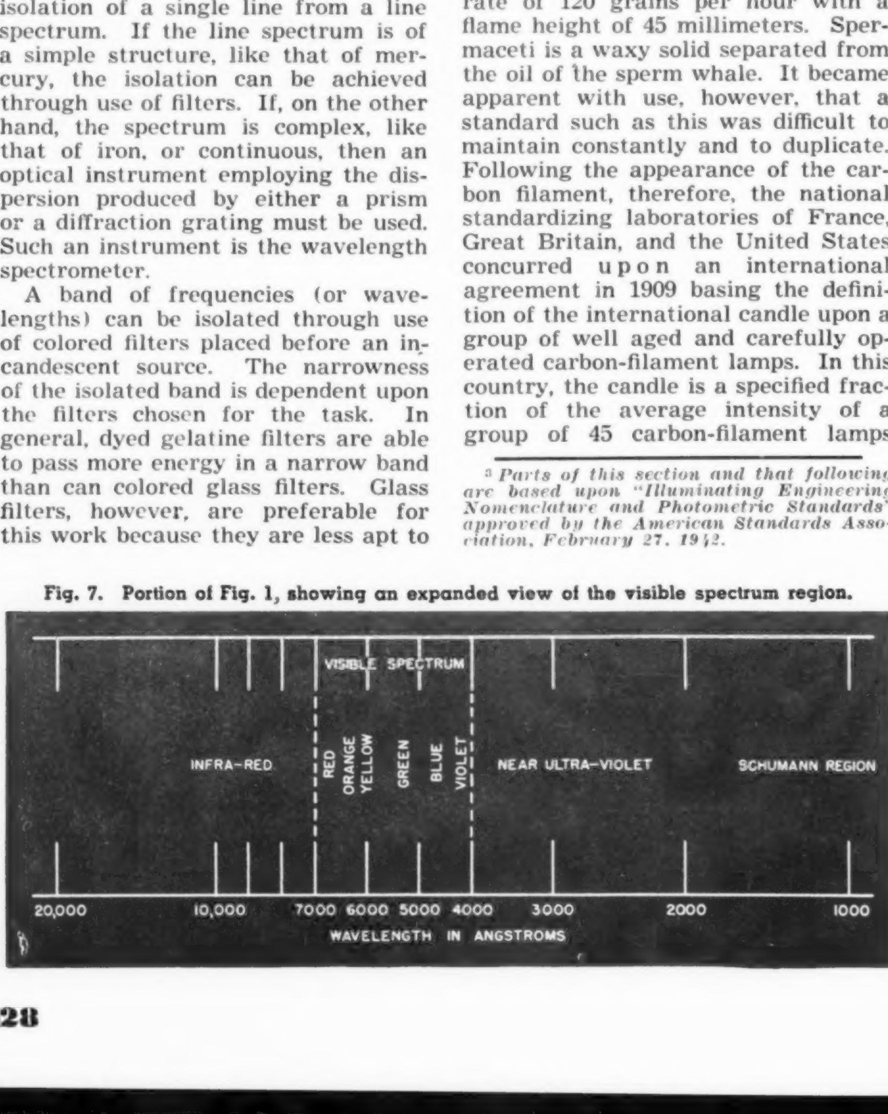
[3] *Parts of this section and that following are based upon "Illuminating Engineering Nomenclature and Photometric Standards" approved by the American Standards Association, February 27, 1942.*

Just as the current through an electron tube can be referred to as a flow or flux of electrons, so can light be regarded as a flow or flux of radiant energy capable of evoking visual stimuli. The time rate of flow of light is called luminous flux, the unit of which is the lumen. The lumen is equal to the luminous energy flowing through a unit solid angle (steradian) from a point source of light with a luminous intensity of one candle. The steradian is defined as that angle included in the cone formed by a circle on the surface of a sphere, the diameter of this circle being equal to the radius of the sphere. (See Fig. 4.) It must be remembered that the point source is but a mathematical concept used to provide the solid angle with a point for its apex. In practical optics, a source can be considered to be a point if the distance from it is at least 20 times as great as its maximum dimension. Since there are 4π steradians in a sphere, a point source emitting light uniformly in all directions radiates 4π lumens per candle. If that sphere were one foot in radius, then the illumination falling upon one square foot of the surface of that sphere would be one footcandle.

The concept of luminous intensity is applicable only when the source is small enough to be treated as a point. In many instances the source is too large for that and the corresponding unit is brightness. As commonly used, brightness usually refers to the intensity of the sensation that results from viewing extended surfaces or spaces. In the photometric sense, brightness is the luminous intensity of any surface in a given direction per unit of projected area of the surface as viewed from that direction. The amount of illumination falling upon a surface is the density of the luminous flux on that surface; it is numerically equal to the luminous flux (in lumens) divided by the area of the surface when the latter is uniformly illuminated.

There are many more photometric units than the four defined, but the purpose of this article is to discuss the general concepts of optics. As the need arises, however, we shall discuss in later sections those units of less basic importance.

Fig. 7. Portion of Fig. 1, showing an expanded view of the visible spectrum region.



Light Sources

Whenever an optical device is used, it is in association with some source of light. In some instances, that light source may be readily apparent, like the lamp in a projector; in others, the light source may be seemingly divorced from it, like the sun in photography. The production and distribution of large amounts of light is now a recognized branch of electrical engineering. The aim of these particular specialists, however, is efficiency and

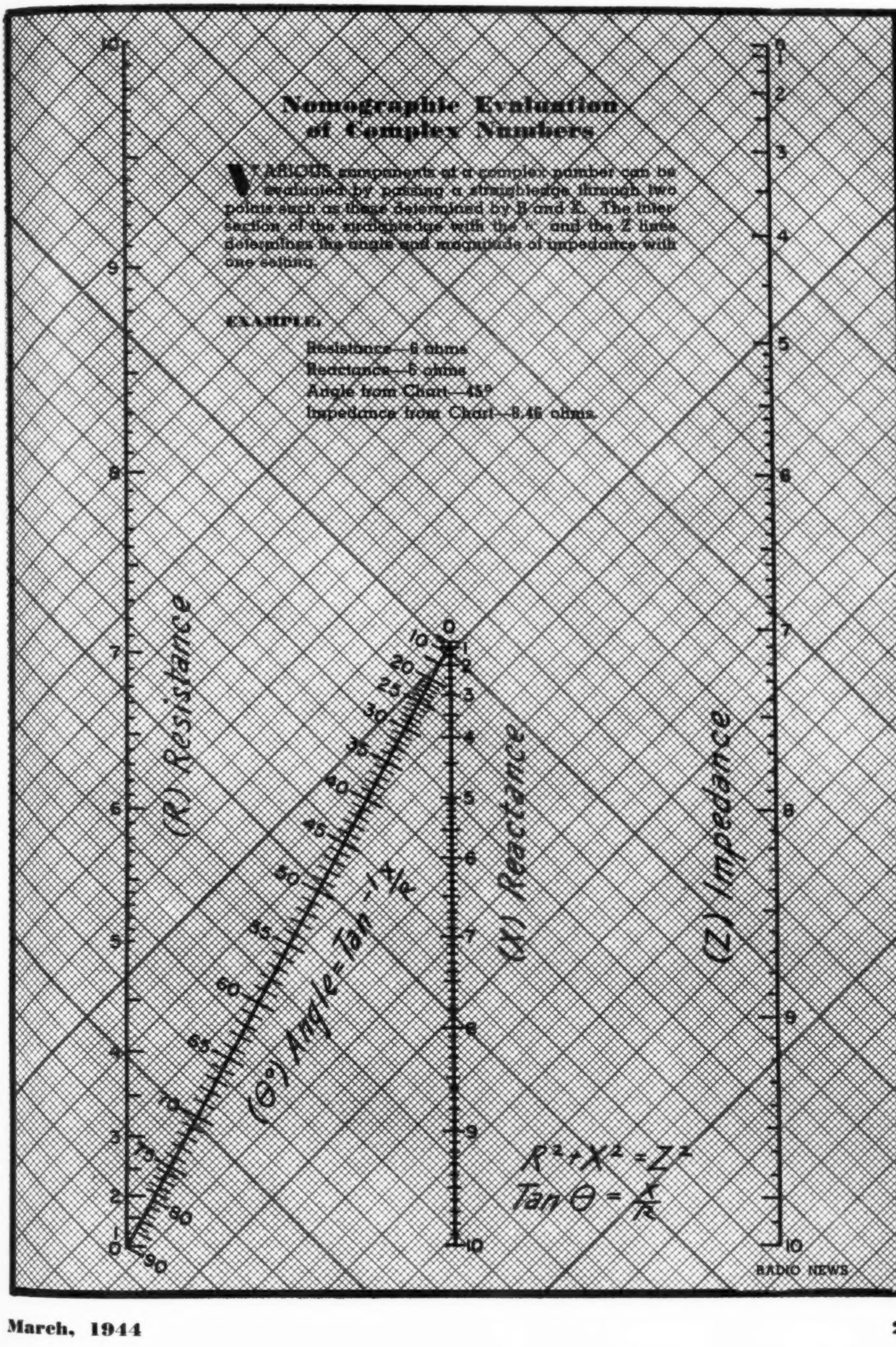
(*Continued on page 74*)

Nomographic Evaluation of Complex Numbers

VARIOUS components of a complex number can be evaluated by passing a straightedge through two points such as those determined by R and X. The intersection of the straightedge with the θ° and the Z lines determines the angle and magnitude of impedance with one setting.

EXAMPLE:

Resistance—6 ohms
Reactance—6 ohms
Angle from Chart—45°
Impedance from Chart—8.46 ohms.



Simple Square-Wave Generator

Constructional details of a simple square-wave generator used to evaluate the amplitude and phase response of an amplifier.

By RUFUS P. TURNER

Consulting Eng., RADIO NEWS

THE subject of fidelity continually offers a puzzle to amplifier servicemen and audio experimenters. It is soon recognized that any but the critically trained ear is a poor criterion and that some sort of instrumentation is therefore necessary. Discriminating builders of audio equipment, amplifiers and otherwise, make frequency runs on their products. But these tests serve only to reveal the frequency-vs.-amplitude response; and occasionally when they yield a flat characteristic, final performance may not be pleasing to the ear. For one thing, the common audio-frequency response tests do not take into consideration phase distortion. And these tests include measurements made with a distortion meter or wave analyzer, as well as those performed with sine-wave oscillator and flat-response output meter.

A signal may be subjected to various phase displacements as it passes through an amplifier or other audio-frequency network. In passing from grid to plate in a single stage, a phase shift of 180 degrees theoretically takes place. Actually, however, this shift may not be exactly 180°, due to the action of circuit parameters, nor is it the same for all frequencies. Since the signal is composed of a fundamental and several harmonic frequencies, and each of these components undergoes a different amount of phase shift, the waveform of the output signal may be expected to deviate from that of the original input signal. This distortion is not evaluated by the common methods of audio-response testing, but is entirely capable of spoiling fidelity.

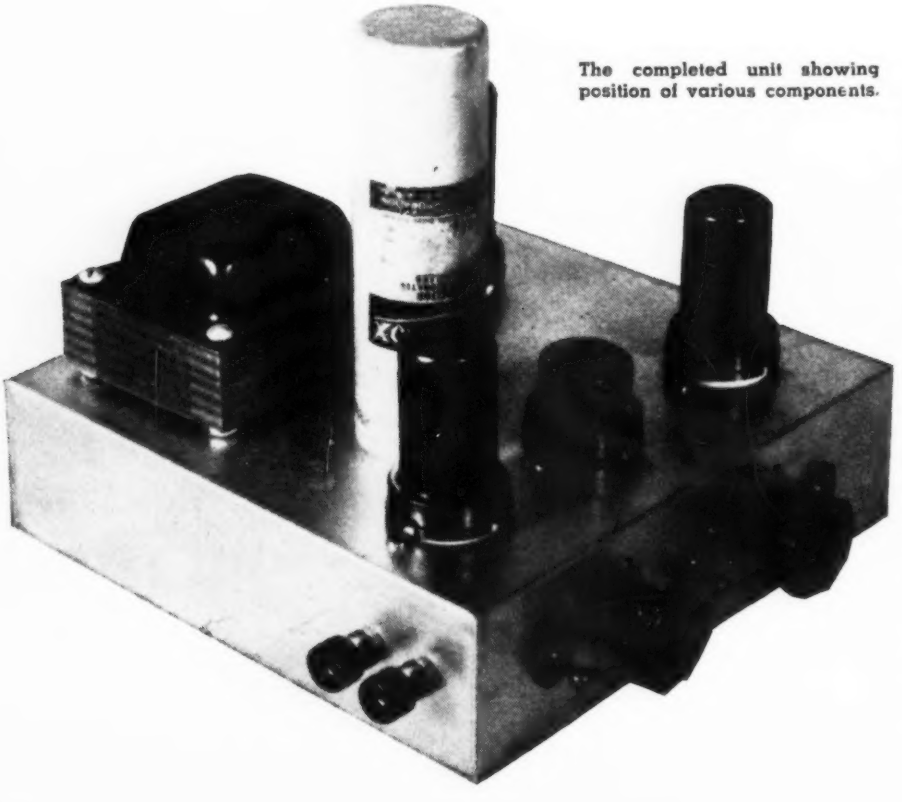
Testing audio systems by means of square waves does take into consideration phase shift, as well as amplitude response. The method is rapid, since one indication reveals the overall response of the system, rather than specifying only a part of the response, and enables both qualitative and quantitative appraisals to be made. The response of an amplifier or network to square waves of appropriate period has been shown to specify completely its response, in phase and magnitude, to a sinusoidal signal of any frequency.

This method of testing consists of applying a square-wave signal to the input terminals of the amplifier or network and observing its pattern oscillographically both before and after the network. The squareness of the waveform will be preserved as the signal passes through the amplifier if the amount of distortion introduced by the unit is negligible. The output-wave shape will deviate from squareness according to the amount and character of the distortion. A rapid means is thus provided for continuous indication while circuit changes are made to improve fidelity.

Response of an amplifier to the square-wave test is explained in the following manner: If a given voltage is abruptly applied to the input terminals and then held constant, the output which results is the *transient characteristic* of the amplifier and this characteristic indicates, as may be shown by operational calculus, response of the amplifier to any type of input voltage. A *unit function* is a unit voltage applied suddenly to the amplifier and then held at a constant level. Amplifier response to a unit function has been shown to specify completely its response to a sine-wave signal of any frequency, in phase and in amplitude.

A square wave of good shape rises sharply to a maximum value, remains at that level for a fixed time interval, drops sharply to a minimum value, maintains that level over an interval corresponding to the maximum period. The cycle is repeated at a predetermined frequency. Such a waveform is shown in Fig. 2. Observe that the wave front of the ideal square (or rectangular) wave is exceedingly steep.

The steep wave front of the square wave corresponds to a train of unit-function voltages, and thus becomes invaluable for testing the transient characteristic of an amplifier or network. The steeper the rise and fall of the waveform and the more uniformly horizontal its flat top, the more closely does the square wave approximate the unit function. One commercially-built square-wave generator provides a complete rise in one-thousandth of a cycle. That is, 16.6 micro-seconds at 60 cy.



The completed unit showing position of various components.

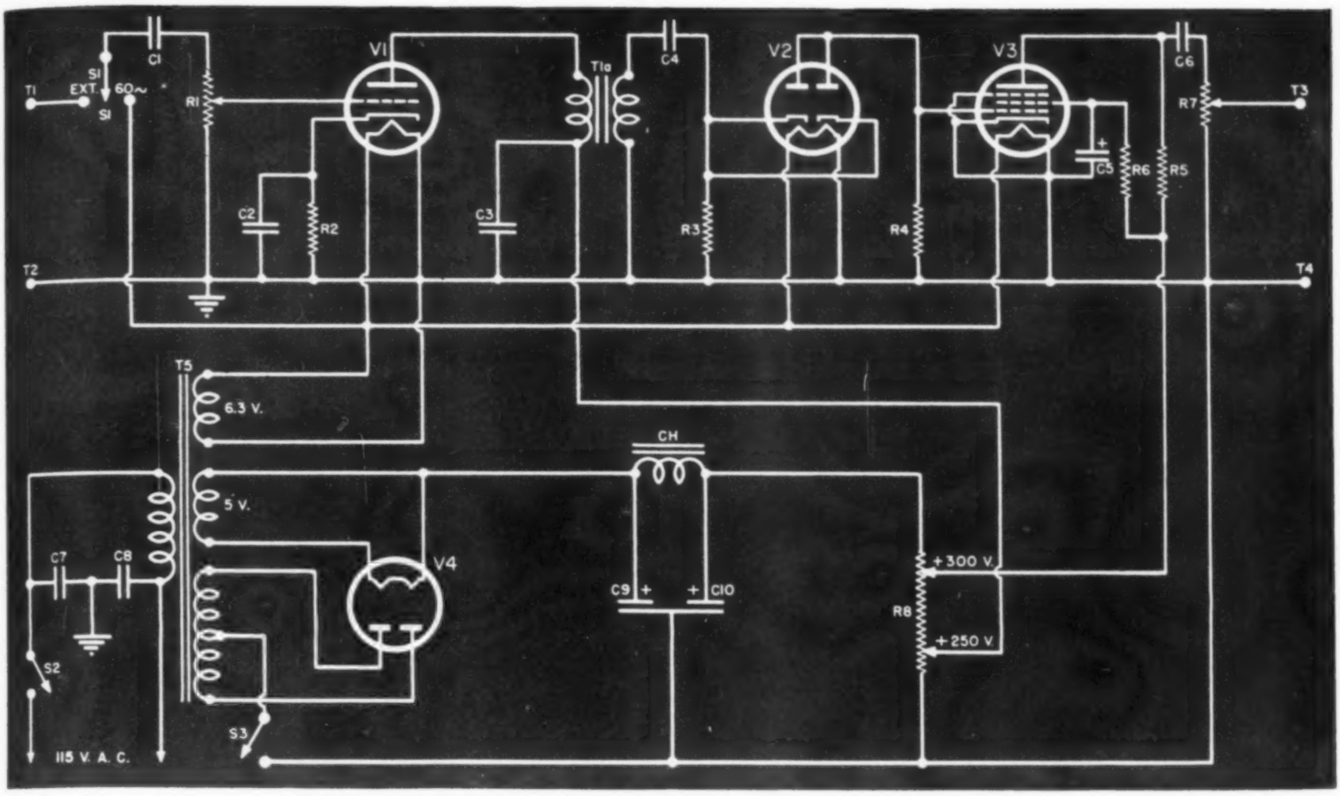


Fig. 1. Wiring diagram of the easily constructed square-wave generator.

C_1—.25-μfd., 200-v. tub.—Aerovox
C_2—25-μfd., 50 d.c.w.v. midget elect.—Aerovox PRS50-25
C_3, C_4—.5-μfd., 400-v. tub.—Aerovox
C_5—8-μfd., 450 d.c.w.v. midget tub. elect.—Aerovox PRS 450-8
C_6—4-μfd., 600-v. oil-filled tub.—Aerovox 610
C_7, C_8—.1-μfd., 200-v. tub.—Aerovox
C_9-C_{10}—Dual 8-μfd., 450 dc.w.v. midget tub. elect.—Aerovox PRS 450-8-8
CH—15-henry, 50-ma. midget broadcast-type filter choke—U.T.C.
R_1—.5-megohm pot.—I.R.C. Type CS
R_2—1000 ohm, 1 watt—Aerovox
R_3—5000 ohm, 1 watt—Aerovox
R_4, R_5, R_6—50,000 ohm, 1 watt—Aerovox
R_7—100,000 ohm potentiometer—I.R.C. Type CS
R_8—10,000 ohm, 25 watt (with two sliders)—Aerovox 952
S_1—S.p.d.t. toggle switch—Arrow
S_2, S_3—S.p.s.t. toggle switch—Arrow
T_1, T_2, T_3, T_4—Insulated binding posts—Gordon
T_1a—Midget 2:1-ratio shielded interstage transformer—U.T.C.
T_5—Power transformer: 350-0-350 v., 50 ma.; 5v., 2 A.; 6.3 v., 2 a.—Utah Z-650
V_1—6C5
V_2—6H6
V_3—6SJ7
V_4—5W4 or equivalent

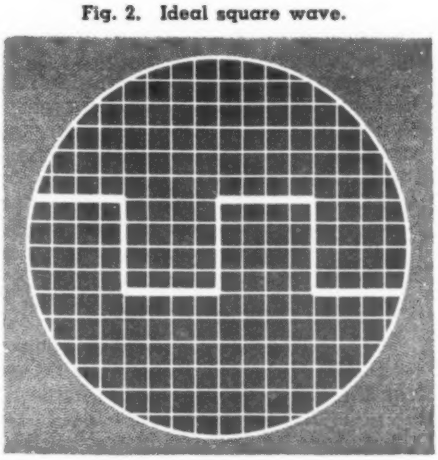
Because of their steep wave fronts, square waves are rich in harmonics. Only odd harmonics are contained, however. The order is 3f, 5f, 7f, etc., rather than the even 2f, 4f, 6f, etc. of other waveforms. The absence of even harmonics should be noted when a suitable frequency is chosen for amplifier testing.

A block diagram of the setup for testing with square waves is shown in Fig. 3. In any other form of test, it would be necessary to connect the vertical-input terminals of the oscilloscope for successive switching between amplifier input and output terminals, in order that the signal waveform might be observed before and after amplification. Here, however, observation of the output-voltage waveform is sufficient, since the generator output voltage may be maintained reliably square regardless of the nature of the amplifier input circuit. However, should it be desired to view both output- and input-voltage patterns *simultaneously* for purposes of dimensional comparison, the electronic switch described in December, 1943 *Radio News* may be employed for the double trace.

The amplifier or network must be terminated in its proper load impedance, and the horizontal-deflection plates of the oscilloscope must be connected to the linear-sweep oscillator operated at the square-wave frequency. The oscilloscope must be of good design, in order that its own vertical amplifiers might not introduce appreciable distortion. Whenever possible, the amplifier output voltage should be impressed directly upon the vertical deflecting plates without amplification within the 'scope. In a number of cases, it will be easy to obtain a sufficient voltage at the amplifier output for operation in this manner.

Several methods have been devised for producing square-wave signals. These have been described fully in the literature by Arguimbau, Bedford and Fredendall, Bowman, Fenn, Reich, Swift, and others. The schemes employed range from blocked-grid amplifier stages to special forms of multivibrators.

Fig. 2. Ideal square wave.



The operating principle of the simple square-wave generator to be described in this article may be understood by referring to the basic circuit diagram of Fig. 4. In this arrangement, square waves are obtained as a result of blocked-grid action in an amplifier stage.

The basic circuit comprises a series-connected half-wave diode rectifier, V_1, which is cascaded with a sharp cut-off pentode amplifier, V_2. The latter is operated at zero bias, its cathode being connected directly to B-minus. A sine-wave input-signal voltage is fed into terminals T_1 and T_2, and a square-wave output-signal voltage is delivered at terminals T_3 and T_4. Resistor R_4 serves as an output attenuator.

Operation of the circuit may be explained in the following manner: A large sine-wave voltage is applied to terminals T_1 and T_2. On positive half-cycles of this voltage, diode V_1 conducts, allowing current pulses to flow through resistor R_2 and to establish a voltage drop across that resistor with the top negative. On negative

(Continued on page 78)

BROADCAST STATIONS AS FREQUENCY STANDARDS

The application of standard broadcast stations for frequency calibrations. This method is simple and sufficiently accurate.

By GUY DEXTER

Test set-up using either a self-excited or crystal oscillator, a meter to observe zero beat, and a radio receiver.

REGULATIONS require that standard broadcast stations maintain their carrier frequencies within plus or minus 20 cycles, irrespective of the frequency magnitude. During operation, broadcast carriers are usually well within these prescribed tolerance limits, never varying from assigned values by more than a few cycles. These facts would indicate that broadcast carriers afford a readily available means for checking calibration of oscillators, frequency standards and similar instruments when a short-wave receiver is not available for WWV reception or when reception conditions impair WWV pickup. The accuracy obtainable by use of these carriers will be suitable for most *practical* electronic purposes.

The instrument generally employed by the experimenter for frequency calibration is a self-excited or crystal oscillator operating at 100 kc. This device is standardized by bringing one of its harmonics to zero beat (by means of a *calibration control* arranged for tuning the oscillator frequency over a narrow band) with some signal of known accuracy. The oscillator may then furnish a multiplicity of accurate spot frequencies by means of which other oscillators, receivers, monitors, signal generators, and similar electronic instruments may be calibrated.

If the standard frequency oscillator is provided with a 10-kc. multivibrator, harmonics of the latter will be available at considerable strength throughout the broadcast band, and any station carrier may be utilized for standardization, since broadcast carriers are spaced 10 kilocycles apart. Most experimental standards, particularly those which are constructed for urgent use, do not embrace a multivibrator stage, however, and only broadcast carriers which are multiples, of 100 kc. may be employed.

For the experimenter's convenience, two tables have been prepared for readily locating broadcast stations which operate on frequencies which are multiples of 100 kc. One hundred and eight broadcast stations operate throughout the country on the following 100-kc. multiples: 600, 900, 1000, 1100, 1200, 1300, 1400, 1500 and 1600 kc. No other even multiples are assigned. Eighty-three of the 108 stations employ carrier frequencies of 1400 kc. Chart I lists these stations alphabetically by call letters. Locations of the station *transmitters* are given in this chart. Chart II lists the same stations by frequencies.

Method of Utilizing

For setting a standard-frequency oscillator, the experimenter should select the strongest carrier available at his receiving location. He should also select the highest-frequency carrier when several of equal strength are available, and must pick the carrier which is free of heterodyne and other interference. The chart will aid this selection. Any broadcast receiver will be satisfactory.

The standard-frequency oscillator is fed into the antenna and ground terminals of the receiver by the loosest possible method of coupling which will pass a signal of sufficient strength into the receiver. As the output circuit of the standard-frequency oscillator is of the low-impedance type which tends to "short" the broadcast signal, coupling should be reduced still further.

When setting to zero beat, it is likely that the process will have to be carried out while a program is in progress. It is desirable, therefore, to reduce the volume to a low level and it will be necessary to recognize zero beat through the music or speech being received. This entails a particularly careful bit of listening. As the beat frequency decreases to a very low value, its low pitch will apparently disappear completely, and this point of disappearance may erroneously be interpreted as zero beat. However, it may be observed by careful listening that a very low beat frequency is still superimposed upon the speech or music, giving the latter a hoarse character. At exact zero beat, all hoarseness and all waxing and waning will

(*Continued on page* 78)

CHART I

Broadcast Stations by Call Letters

Call	Transmitter Location	Frequency kilocycles
KELD	North of El Dorado, Arkansas	1400
KENO	Las Vegas, Nevada	1400
KFPW	Ft. Smith, Arkansas	1400
KFRU	Columbia, Missouri	1400
KFSD	San Diego, California	600
KFVS	Cape Girardeau, Missouri	1400
KGFL	Roswell, New Mexico	1400
KGKL	San Angelo, Texas	1400
KGLO	Mason City, Iowa	1300
KIUN	Pecos, Texas	1400
KIUP	Durango, Colorado	1400
KJBS	San Francisco, California	1100
KJR	Seattle, Washington	1000
KLCN	Near Blytheville, Arkansas	900
KLUF	Near Galveston, Texas	1400
KONO	San Antonio, Texas	1400
KORN	Fremont, Nebraska	1400
KOBH	Rapid City, So. Dakota	1400
KOKO	La Junta, Colorado	1400
KOL	Seattle, Washington	1300
KRE	Berkeley, California	1400
KRKO	Everett, Washington	1400
KRLC	Lewiston, Idaho	1400
KROD	El Paso, Texas	600
KSJB	Jamestown, No. Dakota	600
KSTP	St. Paul, Minnesota	1500
KTEM	Temple, Texas	1400
KTNM	Tucumcari, New Mexico	1400
KTOK	Oklahoma City, Okla	1400
KTSW	Emporia, Kansas	1400
KTTS	Springfield, Missouri	1400
KTUC	Tucson, Arizona	1400
KVFD	Near Fort Dodge, Iowa	1400
KVGB	Great Bend, Kansas	1400
KVOR	Colorado Springs, Colorado	1300
KVRS	Rock Springs, Wyoming	1400
KWLK	Longview, Washington	1400
KWON	Bartlesville, Oklahoma	1400
KWYO	Sheridan, Wyoming	1400
WABY	Colonie, New York	1400
WAGF	North of Dothan, Alabama	1400
WARM	Dunmore, Pennsylvania	1400
WASH	Grand Rapids, Michigan	1300
WATL	Atlanta, Georgia	1400
WATW	Ashland, Wisconsin	1400
WBLK	Clarksburg, West Virginia	1400
WBNY	Buffalo, New York	1400
WBTH	Williamson, West Virginia	1400
WBTM	Danville, Virginia	1400
WCAO	Near Baltimore, Maryland	600
WCBI	Columbus, Mississippi	1400
WCBM	Baltimore, Maryland	1400
WCFL	York Township, Illinois	1000
WCNC	Elizabeth City, No. Carolina	1400
WCOS	Columbia, So. Carolina	1400
WDAS	Philadelphia, Pennsylvania	1400
WDEF	Chattanooga, Tennessee	1400
WDWS	Champaign, Illinois	1400
WELL	Battle Creek, Michigan	1400
WEOA	Evansville, Indiana	1400
WEST	Easton, Pennsylvania	1400
WFBR	Baltimore, Maryland	1300
WFOR	Hattiesburg, Mississippi	1400
WGBR	West of Goldsboro, No. Carolina	1400
WGIL	Galesburg, Illinois	1400
WGRC	New Albany, Indiana	1400
WHBQ	Memphis, Tennessee	1400
WHDF	Calumet, Michigan	1400
WHLB	Virginia, Minnesota	1400
WHUB	Cookeville, Tennessee	1400
WHYN	Hadley Falls, Massachusetts	1400
WICC	Bridgeport, Connecticut	600
WINC	Winchester, Virginia	1400
WINS	Kingsland, New Jersey	1000
WJAC	Johnstown, Pennsylvania	1400
WJDX	Jackson, Mississippi	1300
WJHO	Opelika, Alabama	1400
WJLB	Detroit, Michigan	1400
WJLD	Bessemer, Alabama	1400
WJSV	East of Wheaton, Maryland	1500
WJZM	Clarksville, Tennessee	1400
WKMO	Kokomo, Indiana	1400
WKPT	Kingsport, Tennessee	1400
WKWK	Wheeling, West Virginia	1400
WMAN	Mansfield, Ohio	1400
WMBR	Jacksonville, Florida	1400
WMFD	Wilmington, No Carolina	1400
WMGA	Northeast of Moultrie, Georgia	1400
WMIN	St. Paul, Minnesota	1400
WMSL	Decatur, Alabama	1400
WOAI	Selma, Texas	1200
WOOD	South of Grand Rapids, Michigan	1300
WORD	Northeast of Spartanburg, So. Carolina	1400
WPAY	Portsmouth, Ohio	1400
WRAK	Williamsport, Pennsylvania	1400
WRDO	Augusta, Maine	1400
WREC	Near Rugby Park, Tennessee	600
WRJN	Mount Pleasant, Wisconsin	1400
WRRN	Warren, Ohio	1400
WSAM	Saginaw, Michigan	1400
WSAU	Wausau, Wisconsin	1400
WSBA	North of York, Pennsylvania	900
WSJS	Near Oldtown, No. Carolina	600
WSLB	Ogdensburg, New York	1400
WSRR	Stamford, Connecticut	1400
WTAM	Brecksville Village, Ohio	1100
WTCM	Elmwood Township, Michigan	1400
WWRL	Woodside, L. I., New York	1600

CHART II

Broadcast Stations by Frequencies

600 kc.
KFSD, KROD, KSJB, WCAO, WICC, WREC, WSJS

900 kc.
KLCN, WSBA

1000 kc.
KJR, WCFL, WINS

1100 kc.
KJBS, WTAM

1200 kc.
WOAI

1300 kc.
KGLO, KOL, KVOR, WASH, WFBR, WJDX, WOOD

1400 kc.
KELD, KENO, KFPW, KFRU, KFVS, KGFL, KGKL, KIUN, KIUP, KLUF, KOND, KORN, KOBH, KOKO, KRE, KRKO, KRLC, KTEM, KTNM, KTOK, KTSW, KTTS, KTUC, KFVD, KVGB, KVRS, KWLK, KWDN, KWYO, WABY, WAGF, WARM, WATL, WATW, WBLK, WBNY, WBTH, WBTM, WCBI, WCBM, WCNC, WCOS, WDAS, WDEF, WDWS, WELL, WEOA, WEST, WFOR, WGBR, WGIL, WGRC, WHBQ, WHDF, WHLB, WHUB, WHYN, WINC, WJAC, WJHO, WJLB, WJLD, WJZM, WKMO, WKPT, WKWK, WMAN, WMBR, WMFD, WMGA, WMIN, WMSL, WORD, WPAY, WRAK, WRDO, WRJN, WRRN, WSAM, WSAU, WSLB, WSRR, WTCM

1500 kc.
KSTP, WJSV

1600 kc.
WWRL

MINE LOCATORS

The problems encountered by Britain's Ministry of Supply in producing an effective electrical mine detector.

By CONNERY CHAPPELL
British Journalist and Author

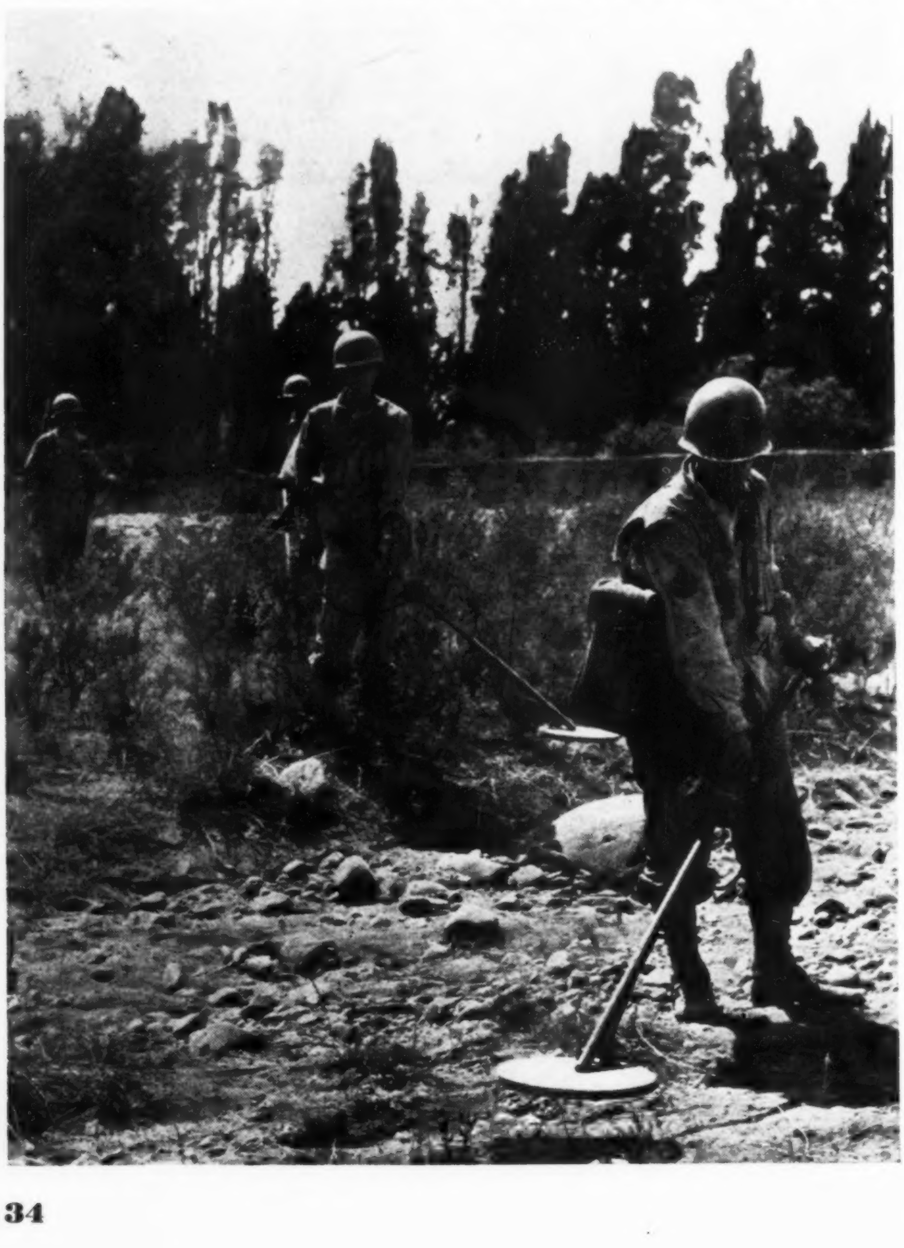
COMPARED with the complexities of aircraft or naval design, the mine detector is an extremely simple, almost elementary job—consisting as it does of a mere 250 components, involving 29 subassemblies.

In battle it has proved enormously valuable; it speeds up the operation of clearing a land minefield, and helps the attacking force to maintain its momentum.

The principle of the electric mine detector is simple: it is based on the familiar idea of the balanced magnetic fields. Two coils are placed close together; a current passes through one and sets up a second electric field through induction. The two fields are equally balanced and give no reaction—but create an oscillating signal if the balance is upset by a metallic object. The soldier operating the detector hears a different note on his earphones and knows that he is near metal.

When the demand for a mine detector first became urgent, the task of producing one was turned over to the research branch of *Britain's Ministry of Supply*, which soon had nine different experiments in hand. The basic principle was apparent from the start; the problem was to devise an instrument that would stand up to the roughest conditions of active service, would not weigh more than a reasonable additional load for a soldier in battle equipment, be foolproof in operation, require only a minimum operating team, and be composed of simple interchangeable parts allowing for quick replacement.

American-made mine detectors being used to clear out mine field near St. Stefano, Sicily.



At the beginning of October, 1941, the research sections of the Ministry of Supply were nearing the final stages of their experimental work, and trials had been fixed for October 25. But on October 13 they received particulars of a new model produced independently by two lieutenants in the Polish forces.

It was obvious at once that the Polish design was very good. It embodied no startling principles; there was nothing new in its approach. But its actual layout suggested advantages from the point of view of manufacture and operation. So it was decided to base the trials on this design, and the Ministry was left with a week in which to produce a trial model.

A London radio firm was chosen; Ministry research engineers moved into the factory; special laboratory facilities were provided; the firm's own research men co-operated. By working more than twelve hours a day they produced the first electric mine detector in time for its trial.

The tests were satisfactory, and the usual prolonged field tests were started. But the need was urgent, and the Ministry decided to take a chance. Assuming that the results would be satisfactory, an order was placed for the finished article. Production started at the beginning of December, 1941; special steps were taken to speed things up so that there would be a supply of detectors in the Middle East before bulk supplies came through.

Externally, the detector consists of a flat plate, known as the search probe, with rounded ends, about 15 inches long, 8 inches wide and three-quarters of an inch deep. A movable shaft is fixed into the center of the upper plate, and there are two control knobs on the handle of the shaft. The remainder of the equipment is contained in a haversack on the operator's back.

Inside the haversack are the oscillating and amplifying circuits, the sensitivity control and the high and low tension batteries. A cable runs up the shaft from the search probe; the headphones, when not in use, are stowed in a separate compartment in the haversack.

There are two electric coils inside the probe. They occupy each of the rounded ends of the probe and slightly overlap. They are held rigidly in position by wax. If they are moved out of position at all the balance of the

(*Continued on page* 73)

PANORAMIC RECEPTION

The S-35 panoramic adapter and SX-28 communications receiver mounted as a unit.

By C. T. READ

Eng. Dept., The Hallicrafters Co.

☆

An adapter unit used in conjunction with a communications receiver for visual observation and analysis of the radio-frequency spectrum

☆

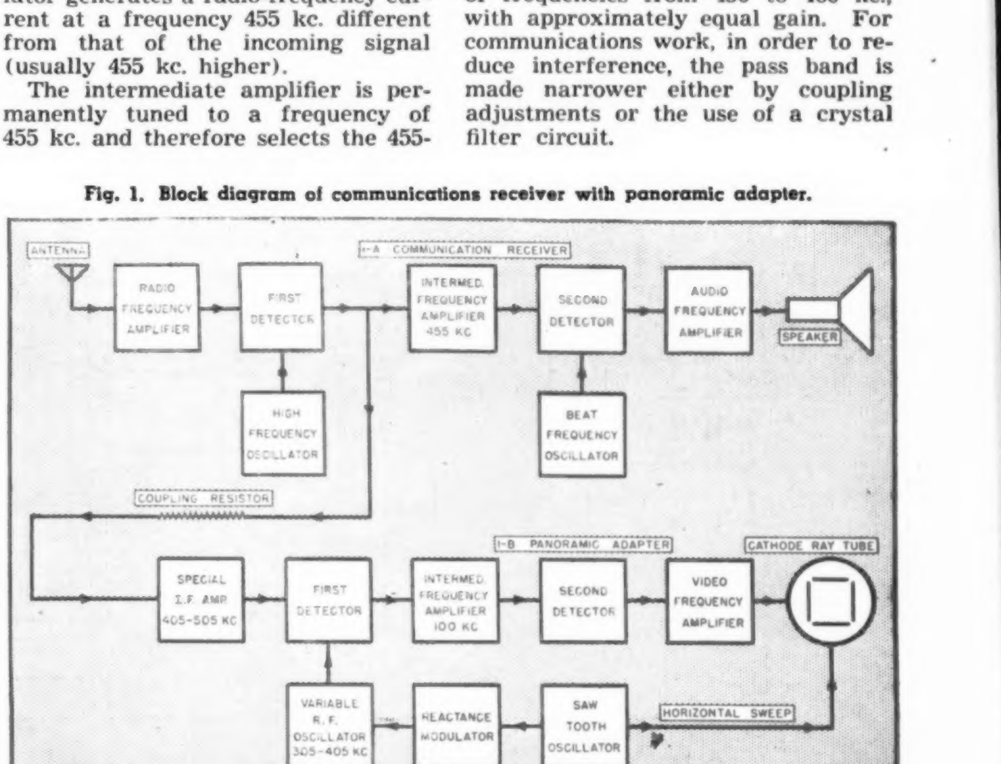
THE panoramic radio receiver is one of the newest and most interesting applications of the cathode-ray tube. As announced by the *Hallicrafters Co.* a few months before Pearl Harbor, it took the form of an auxiliary unit designed to work in conjunction with a standard receiver, usually their Model SX-28. The necessary power supplies, intermediate frequency and video-frequency amplifiers, sawtooth oscillator, reactance modulator, and cathode-ray tube, are all mounted on a panel and chassis of approximately the same size as the SX-28. Both units are installed in a metal cabinet with the Model S-35 Panoramic Adapter on top. (See illustration.) Only one electrical connection is made between the two units and the panoramic adapter does not interfere in any way with the normal operation of the receiver.

Before proceeding with an explanation of panoramic reception, it will be helpful to review the fundamental principles of the super-heterodyne. Fig. 1 is a simplified block diagram of a super-heterodyne communications receiver. Disregarding the panoramic adapter for the time being, the operation of the circuit is as follows:

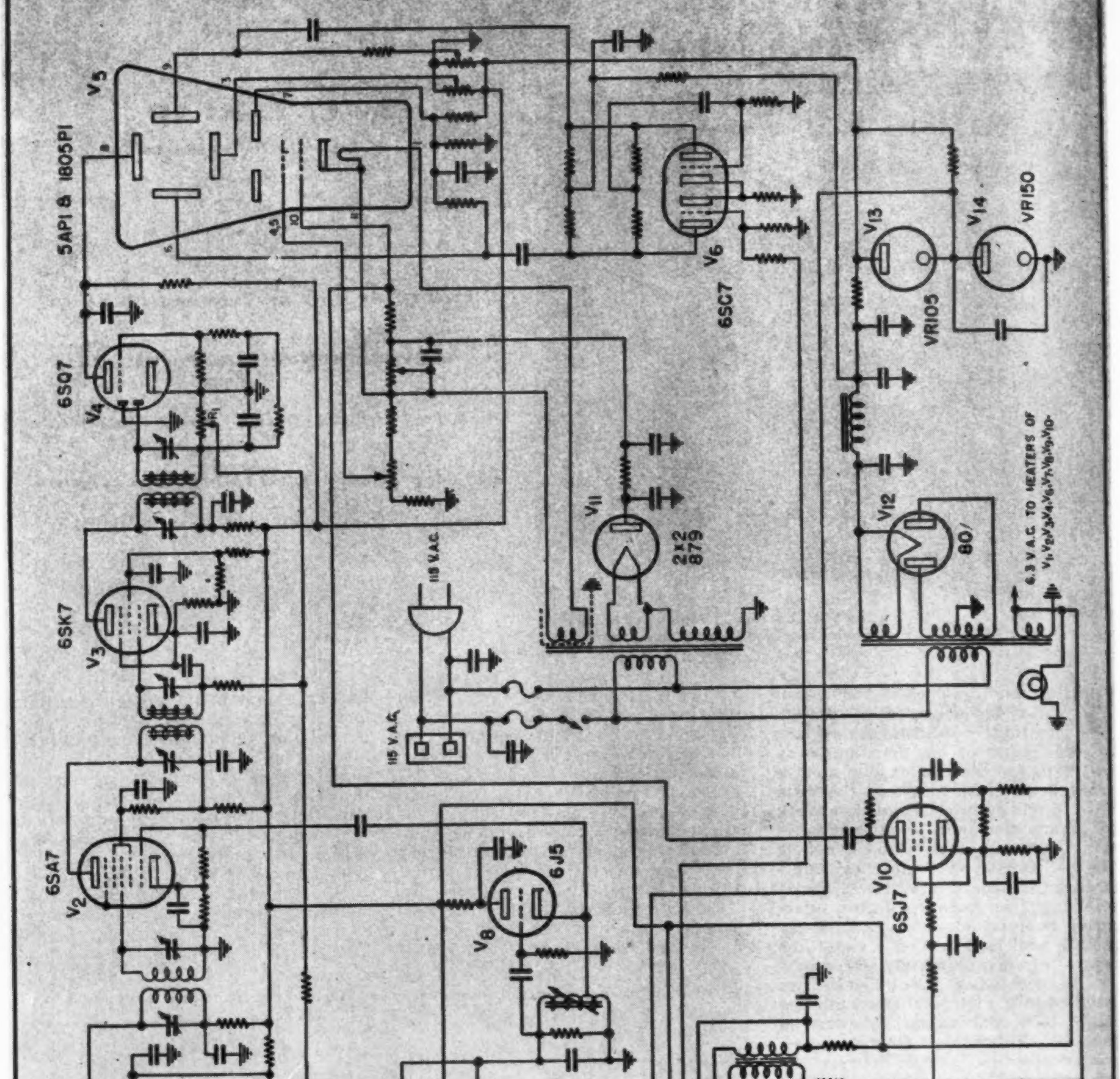
Radio-frequency currents induced in the antenna are fed into the radio-frequency amplifier which is tuned to resonance at the frequency of the desired signal. The amplifier's output goes to the first detector or mixer which also receives the output of the high-frequency oscillator. As the first detector is a non-linear impedance, the two incoming signals (radio signal and output of oscillator) combine, and the detector's output contains the original radio frequency, the oscillator frequency and the sum and difference frequencies of the two. In the SX-28, the high-frequency oscillator generates a radio-frequency current at a frequency 455 kc. different from that of the incoming signal (usually 455 kc. higher).

The intermediate amplifier is permanently tuned to a frequency of 455 kc. and therefore selects the 455-kc. component in the detector output and amplifies it. This 455-kc. component has all of the characteristics, modulation, etc., of the original signal. For high-quality broadcast reception the intermediate-frequency amplifier is adjusted to pass a band of frequencies from 450 to 460 kc., with approximately equal gain. For communications work, in order to reduce interference, the pass band is made narrower either by coupling adjustments or the use of a crystal filter circuit.

Fig. 1. Block diagram of communications receiver with panoramic adapter.



Schematic diagram, Hallicrafters S-35 panoramic adapter



The output of the intermediate-frequency amplifier goes to the second detector where the audio frequency appears. In the case of phone or other modulated signal reception, the second detector acts as a rectifier and simply recovers the audio-frequency modulation of the incoming signal. When CW telegraph signals are being received the beat-frequency oscillator is turned on and adjusted to a frequency differing from the intermediate frequency by the desired audio frequency (usually 500 to 1000 cycles). The second detector combines the two frequencies and the resulting audio frequency is amplified again and then converted into sound in the loud speaker.

The panoramic adapter makes use of the super-heterodyne principle but its circuit operation is much more involved than that of the ordinary receiver. As can be seen from Fig. 1 a small part of the first detector output of the communications receiver is transferred to the panoramic adapter through a coupling resistor. This output is fed into a special 455-kc. I-F amplifier of unusual characteristics. As the panoramic adapter is designed to show all incoming signals within a range of 50 kc. on either side of the frequency to which the receiver is tuned, it is obvious that this amplifier must pass a band of frequencies 100-kc. wide. In addition it must provide greater gain in the outer portions of the band than at the center in order to compensate for the inherent selectivity of the radio-frequency amplifier and first detector of the communications receiver. Fig. 2 shows the selectivity curves of a radio-frequency amplifier and Fig. 3 is the approximate gain vs. frequency curve of the special intermediate-frequency amplifier in the Hallicrafters Model S-35 Panoramic Adapter. As shown in Fig. 2, the selectivity of a radio-frequency amplifier decreases with increasing frequency so it is impractical to compensate exactly over the entire range of the receiver. In the Model S-35 the special intermediate-frequency amplifier is designed for uniform compensation at an r-f signal input to the receiver of approximately 5 mc. At lower input frequencies, the selectivity of the receiver's R.F. and detector stages increases and as the amplification characteristics of the panoramic special I-F amplifier remain constant, the over-all gain at the output of the panoramic first detector is greater at the center of the 100-kc. pass band than at either edge. At higher input frequencies, the selectivity of the receiver's input circuits decreases and the panoramic input amplifier over-compensates with the result that the outer portions of the band have slightly higher gain than the center.

The output of the special intermediate-frequency amplifier containing all signals within a range of 50 kc. on either side of the signal to which the communications receiver is tuned is fed into the first detector of the panoramic adapter. This detector also receives the output of the panoramic variable radio-frequency oscillator and combines the two, exactly as in ordinary super-heterodyne action.

At this point the principal difference between the panoramic adapter and the conventional super-heterodyne becomes apparent. In the ordinary receiver the high-frequency oscillator is designed for maximum stability; whereas, in the panoramic adapter the oscillator frequency is constantly varied by means of a reactance modulator. The normal oscillator frequency is 355 kc. but under the control of the reactance modulator it continually sweeps across a band of frequencies from 405 to 305 kc.

The panoramic intermediate-frequency amplifier is sharply tuned at 100 kc. and has a band width of less than 2000 cycles. It is evident that

(*Continued on page* 64)

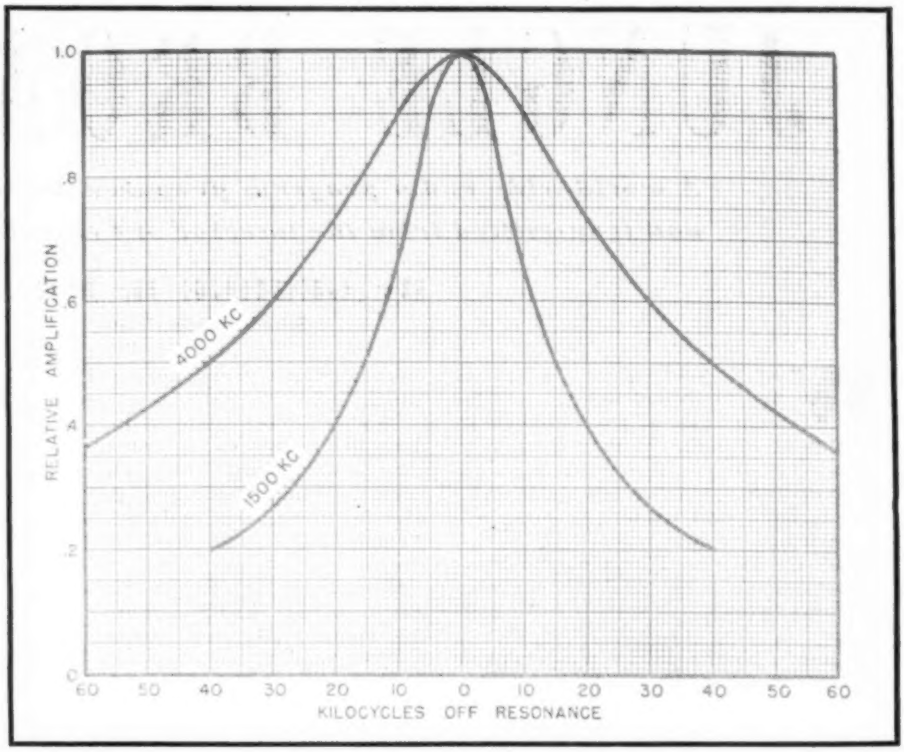
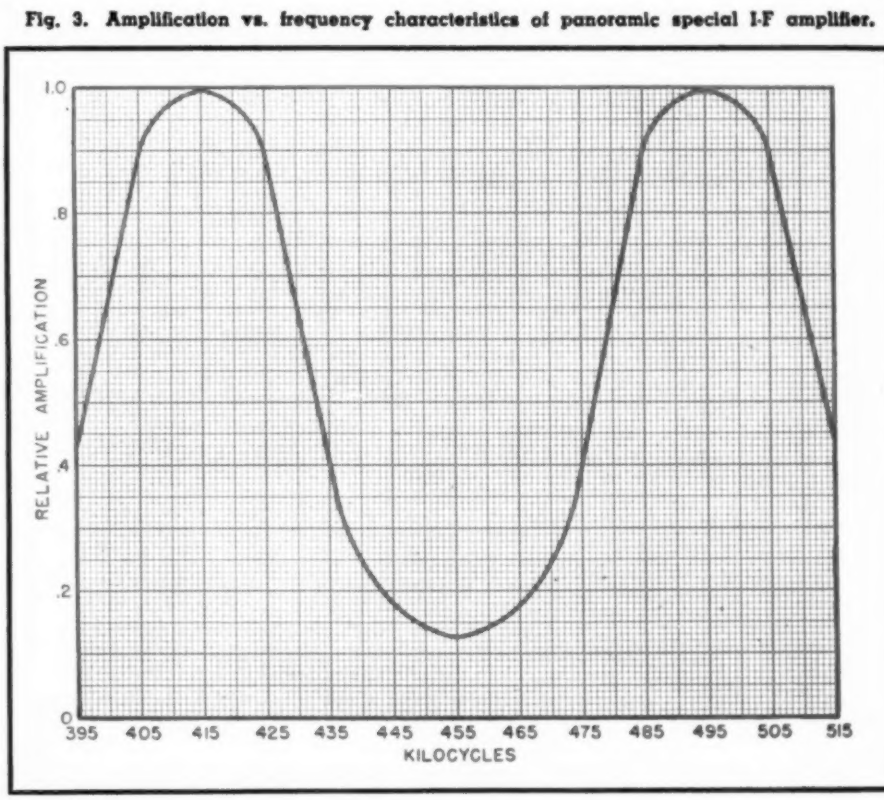


Fig. 2. R-F amplifier characteristics showing variations in selectivity with respect to frequency.

Fig. 3. Amplification vs. frequency characteristics of panoramic special I-F amplifier.



JUNGLE BROADCAST

A world-wide radio program prepared by our Armed Forces and transmitted from the interior of Central American jungles.

By GEORGE B. HILL
Panama Canal Zone

WHEN soldiers at a small Army broadcasting studio were asked to take their equipment into the jungle, arrange a 75-mile remote control circuit through some of Central America's most difficult terrain, and present a program to be heard around the world, workers at the Armed Forces Radio Station scratched their respective heads, and asked for a few days to think it over.

Panama Mobile Force was preparing the first world-wide radio program from Panama's jungles—a realistic picture of jungle combat training—and the problem dropped in the AFRS lap was so complicated at first glance that it seemed almost impossible. There could be no "boosters" on the 75-mile line. Jungle mud would prevent any wires being strung on the ground. Something might go out anywhere along the circuit. Explosions of mortar shells, bangalore torpedoes, or TNT might knock a line out or damage a microphone, for all sound effects were to be the real thing.

It was almost like putting through a radio program on a prayer. Signalmen throughout the Department promised help and two days later, Mobile Force was notified that the Army's radio men were willing to try it.

When Sergeant Ewald Wyberg, engineer of the AFRS, began to check the coming 20-minute broadcast, he found troops were to go through two problems in a rugged Atlantic-side area. It was in the hilly and swampy Panama terrain, which does not have to play second fiddle to any jungle for being bad. Announcers were to describe the action on the spot—just as it happened. That was the only easy part of the broadcast, except that even the announcers were to find themselves slopping through heavy mud for almost a mile to complete their speaking parts.

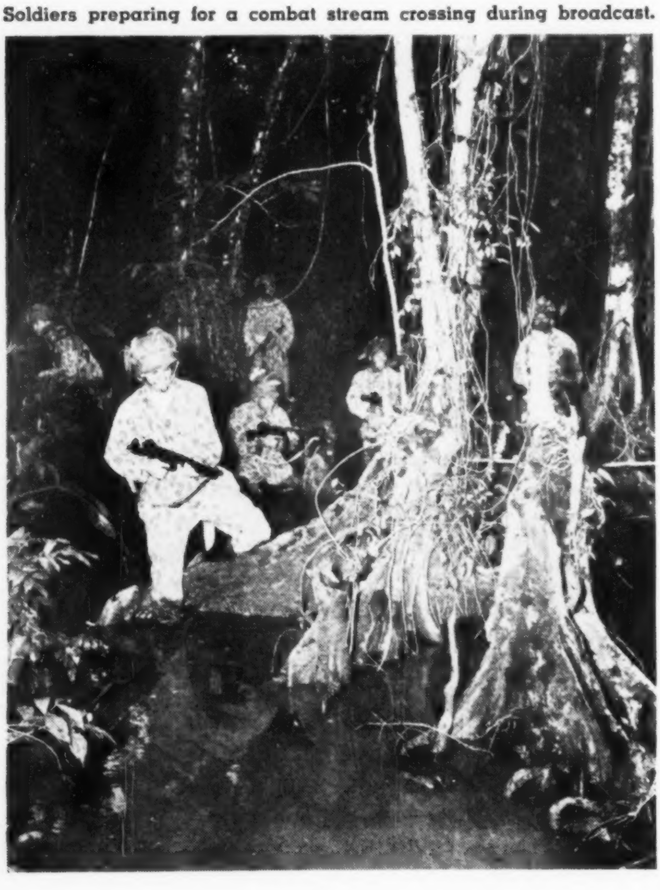
The 75-mile setup was completed by Signalmen, co-operating with Wyberg, and on the day of the broadcast—November 14—soldier helpers carried about 600 pounds of equipment up a slippery trail to put it in position while Signalmen climbed through lush branches to make jungle phone poles of the tropical trees.

Five miles away, the second problem was to fill the program's remaining 10 minutes, beginning as the first ended.

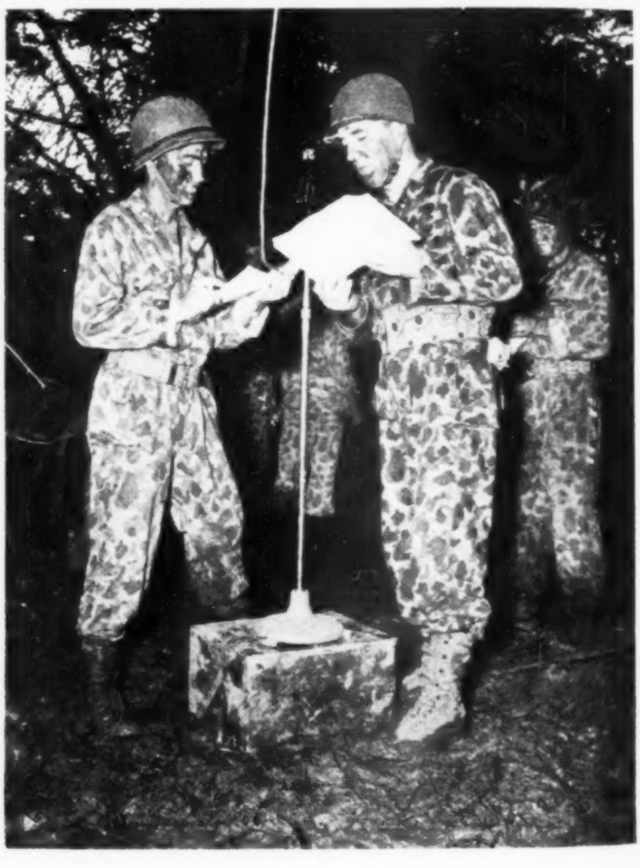
Sgt. Wyberg took over Problem No. 1's technical end and Sgt. Jim Weathers, formerly with WAGF at Dothan, Alabama, took the mike. The broadcast from this area was to be made from a small hillside overlooking a maze of undergrowth, fallen trees and barbed wire entanglements facing three Jap-type pillboxes.

The second area was a swampy, mud-filled strip of dense undergrowth, vines and slush beside a tropical river, which had recently gone out of banks several times because of the rainy season, then in full swing. Here, expert Infantry swimmers were to make

Soldiers preparing for a combat stream crossing during broadcast.



Announcers describe stream crossing made under simulated offensive.



Announcer pinch-hitting at the controls.

Part of the equipment carried by the Panama Mobile Force Infantry and Engineer troops.

a stream-crossing assault on the opposite bank. Sergeant Charles (Chuck) Bras, who was radioing with KOMO and KJR at Seattle before that morning in December, 1942, when the President sent him "Greetings," stood in mud well above his ankles to make the description of the crossing.

2nd Lt. Mark Braymes, AFRS manager formerly with Mutual out of New York, crossed his fingers and predicted "our biggest flop or our biggest success."

Worrying over, everything went right—as right as things can go in a mass of mud and vines. Helpers brought heavy dynamos into place, after the portable power plants had been carried by truck for more than 50 miles. Amplifiers were packed down trails which one ex-southern farmer, now a Mobile Force jungle soldier, described as a "big pig pen," and beside swampy waters which ducks, wisely enough, have never been known to enter.

One of the chief problems, after the setup was made, was sound. There were to be no artificial sound effects. A crucial point in the program, however, brought out one which was unscheduled, but necessary. Weathers described the action: Mortar shells softening pillboxes; machine guns and riflemen opening up to drive the "enemy" into his hole and neutralize opposing fire; jungle troops preparing to move through the wire, bringing up a bangalore torpedo to blast the hole; Infantrymen pouring through. An engineer flame thrower and a pole-charge man crept toward the pillbox. The flames leaped toward their objective and the pole charge went into place. At this crucial point, Weathers paused. The charge failed to go off. Captain Robert B. Winkler, twice-decorated veteran of

(*Continued on page* 72)

Technical assistant at a remote outpost during the realistic training-maneuvers broadcast.

TECHNICAL BOOK & BULLETIN REVIEW

FUNDAMENTALS OF TELEPHONY. by Arthur L. Albert. Published by *McGraw-Hill Book Company*, New York and London. 374 pages. Price $3.25.

This is an elementary book, intended for students and telephone workers, and is devoted exclusively to telephone communications. Because most of the readers will not have had extensive training in electricity, the first three chapters present basic electrical theory. The fourth chapter is devoted to sound, speech, and hearing. Much of the material in these chapters is taken from a previous book of the author's: "Electrical Fundamentals of Communication," and many of the illustrations, examples, and diagrams are from that book. Caution is advised to those who have read the previous book that although it is advisable to pass over these opening chapters, care should be taken not to overlook essential material, because much information pertaining directly to telephony appears in the first four chapters.

The following chapters consider such subjects as telephone transmitters, receivers, telephone sets and circuits, telephone lines, manual telephone systems, dial telephone systems, loading, telephone measurements, noise and cross-talk, and repeaters and carriers. At the end of each chapter are review questions and problems to assist the student.

THE TECHNIQUE OF RADIO DESIGN. by E. S. Zepler. Published by *John Wiley & Sons, Inc.*, New York. 312 pages. Price $3.50.

This book conveys to the reader some of the experience of a radio designer, obtained over a number of years in a large works laboratory.

It deals mainly with those problems which are closely linked with the daily routine work of an engineer, both in the development and testing of radio-receiving apparatus of all types. Intimate details of many aspects of receiver work are given rather than a comprehensive treatment, general principles being left to textbooks.

The technique of experimental work begins where unexpected complications occur; where a circuit behaves in a manner not predicted from the circuit diagram. On the other hand, the technique of design consists in forseeing these complications and being able to work out on paper the electrical circuit and mechanical construction, so that serious trouble is not likely to occur. The principal aim of this book is to develop qualities necessary for such work, i. e., a feeling for the right order of magnitude, a quick grasp of essential facts and common sense in approaching the problems.

(*Continued on page* 113)

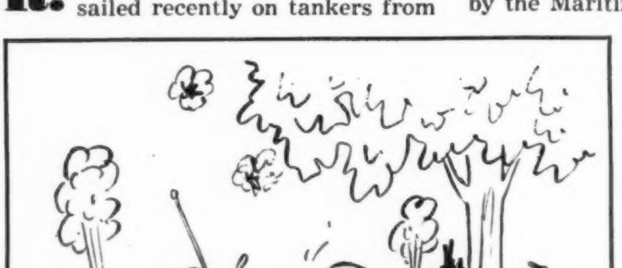
By CARL COLEMAN

THE first "Victory" ship of the United States Merchant Marine, the start of a fleet which is expected to become the mainstay of the postwar cargo ships, was launched in January at the Oregon Shipbuilding Corporation operated by Kaiser. The new vessel christened "United Victory," is more rakish and faster than the "Liberty" ships, making about four knots more; carrying capacity is about the same as that of the production line products. The new vessels will make a round trip across the Atlantic in about three weeks as compared to the Liberty's time of nine weeks. The Victory will of course, however, be slower in construction, taking much longer than the usual thirty days consumed in the construction of the Liberty. We have not, as yet, seen the layout of the radio shack on this type vessel, but at least it will be an improvement over the Liberty type, we sincerely hope—with all the complaints that came in from the older models better rooms and conditions should be found. The Liberty with the "mill" on the wrong side, poor ventilation, lack of heat in cold weather, and other difficulties certainly received its share of objections from the boys.

R. McWHIRTER and M. Tilley sailed recently on tankers from the East Coast. Leif Bye took out another cargo job from an Atlantic Coast port after an extended vacation ashore. A. J. Gashett is also out on a freighter, a new assignment. Bob Lacey is in from a short tanker trip after his short stay ashore. H. O. Andersen went out on a tanker also recently, likewise H. Racutersen. H. Harris is still sticking to his cargo job where he has been for over three years.

MANY inquiries regarding entering the U. S. Maritime Service have been received so the following information may be of some help to those wanting to get into this outfit and take their radio training course. First off, Maritime reports that the only school now open is the one at Gallups Island up in Boston Harbor; the pre-training school at Huntington, Long Island has been closed. Formerly students were sent to Huntington for a short course which was followed by five or six months at Gallups Island for finishing off before spending a few days in the local FCC offices to get that ever so essential "ticket."

New course entirely at the "Island" school in Boston is about seven months on the average, as reported by the Maritime Service, N. Y.


"The next bright idea I have, I'll keep to myself!"

The U. S. Maritime Service is looking for men 18½ years of age to 37½ years of age for these training courses and will not accept you unless you are within these age limits. A man is assigned a station for five weeks, after which he is given an aptitude test. This examination is competitive and those with the highest marks are assigned to the school to the extent of its capacity. Others are assigned to other branches of service. There is, in other words, no guarantee that you will be given radio training, or, for that matter, assigned to radio in any case. It's a case of the best man winning.

(*Cont'd on page* 106)

THEORY AND APPLICATION OF U.H.F.

by MILTON S. KIVER

Part 3. Fundamental theory and operation of the transit-time and negative-resistance magnetron ultra-high frequency oscillator tubes.

IN ORDER to appreciate the mechanism of the magnetron, several ideas must first be developed. As is well known, the electron travels to the plate of a tube when the potential applied to the plate is positive. Its path in this case usually is a straight line, this being the shortest distance between the cathode and the plate. The electron will be attracted to the plate whether the electron is at rest or in motion.

Now let us consider what happens to an electron when it is in motion and only a magnetic field is present. If the motion of the electron carries it

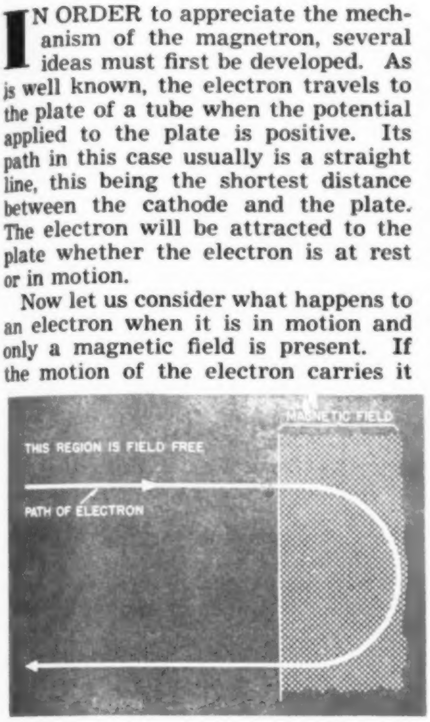


Fig. 1. Path of an electron as it is projected into a magnetic field.

parallel to the lines of flux of the magnetic field, then the magnetic field will exert no force whatsoever on the electron. If the electron is at rest then the magnetic field will exert no influence on the electron and it will remain at rest. However, if the electron velocity has some component normal to the lines of flux of the magnetic field, then the electron will be acted on. Referring to Fig. 1, suppose the electron enters the magnetic field at right angles to the field. Then the force acting on the electron will cause it to travel in a circular path. In the case chosen, it left the magnetic field before it could complete the circle, but if the entire space were under the influence of the magnetic field, the path of the electron would have been a true circle. It can be shown by simple considerations that the radius of the path is directly proportional to the speed of the particle. Furthermore, the period and the angular velocity are independent of speed or radius. This means that faster-moving particles will travel in larger circles in the same time that a slower moving particle moves around its circle.

If now we come to the situation found in the magnetron where the magnetic and electric fields are usually at right angles to each other, an electron travelling in this combined field with some of its motion at right angles to the magnetic field will describe a helical path. This type of path can best be visualized if one imagines the electron as travelling in a circle and at the same time also moving forward. The best mechanical device that describes this type of motion is a screw being put into a wooden board. Its motion is circular, yet it is always moving forward.

In the magnetron the electron is emitted by the filament and is attracted to the plate. However, due to the magnetic field present it describes a path such as is pictured in Fig. 2. As the value of the magnetic field increases the electron describes circular paths with decreasing radii, until finally the electron no longer hits the plate and the plate current stops. It is at this point in the phenomenon that the magnetron becomes useful as will be described in the following paragraphs.

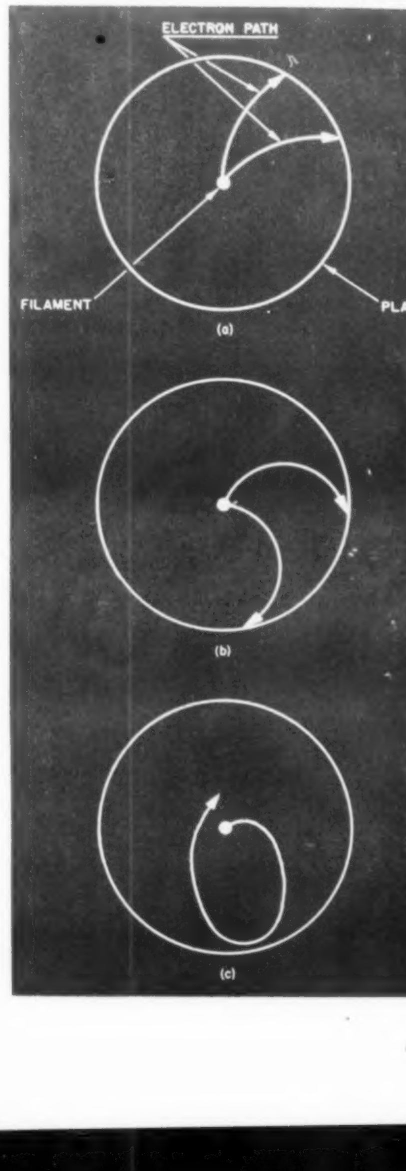
Having shown what a magnetic field of force can do to an electron, a review of the principles and circuits of a type of ultra-high frequency generator known as the magnetron may be given. The device called the magnetron by Hull was developed in 1921. As first used it consisted of a cylindrical plate structure and a coaxial filament, with a uniform magnetic field directed along the electrode axis. The magnetron most widely in use today differs from the above only in having the plate structure split lengthwise in two and appropriately called the "split-anode magnetron." The field set up by the magnetic coil is usually constant in value although alternating magnetic fields have also been experimented with. The best results, however, are received with the steady field.

The magnetron used as an oscillator can be divided into two types—one is the type known as the negative-resistance magnetron oscillator and the other is the transit-time oscillator. The negative-resistance magnetron, or dynatron magnetron as it is sometimes called, actually operates for a portion of its characteristic curve as a negative resistance and hence, will sustain oscillations. Its action is somewhat analagous to the tetrode where the plate current actually decreases for small increments of its plate voltage. The frequency of the negative-resistance magnetron oscillator is less than the second type—the transit-time oscillator. In the transit-time oscillator the frequency of oscillation is determined by the vibration of the electrons between the filament and the plate segments.

The Negative-Resistance Magnetrons

The basic idea of the negative-resistance magnetron was brought out by

Fig. 2. Electron path from cathode to plate in a magnetron tube. (a) With weak magnetic field causing circular electron path. (b) Increased magnetic field. (c) Strong magnetic field preventing electron from reaching plate.



Habann in 1924 and the arrangement shown in Fig. 3 was developed by Manns in 1927. In the figure it can be seen that each tuned circuit (there are really two) is placed between the filament and a plate segment. Although the tuned circuit shown consists of a coil, condenser and the inherent resistance of the circuit, actually a Lecher-wire system is used since ordinary coils and condensers are pretty nearly useless at the ultra-high frequencies. In order to start oscillations the magnetic field is increased to slightly above the point where the electrons just graze the plate. The first value at which the electrons miss the plate is known as the critical value. The formula usually given for the critical magnetic field is:

$$H_c = \frac{6.72}{R_a} \bullet \sqrt{E_p}$$

where:

R_a = plate radius in centimeters
E_p = plate potential in volts.

Once oscillations have been started, the value of the magnetic field is not critical and may be varied over a wide range. The oscillation frequency is essentially determined by the natural resonant frequency of the external tuning system. In order to obtain good efficiency with this type of oscillator the electron transit time should be kept to 1/10 or less of the oscillating frequency. This is also true for ordinary negative-grid triode oscillators. The importance of these negative-resistance oscillators is due to their large power output and high efficiency even at fairly short wavelengths. It has been reported that using air-cooled tubes, power outputs of the order of 50 watts or so, has been attained at a wavelength of 50 centimeters and when water cooling of the tube was resorted to, several hundred watts of power output were obtained with an efficiency between 40 to 55 per cent.

Referring again to the oscillator, let us see just how a negative resistance is obtained. The explanation can be found by referring to the volt-ampere or static characteristic curves of the split-anode magnetron shown in Fig. 4. These curves can be obtained experimentally by increasing the potential of plate A by small amounts and, at the same time, decreasing the potential of plate B by a corresponding amount. In this way conditions similar to actual operations are obtained. When the currents to the plate segments (in this case i_A and i_B) are measured, it is found that more current flows to plate B than to plate A even though plate B is at a lower potential than plate A. Furthermore, as this difference between plate potentials (E_A - E_B) is increased, up to a certain point, the excess of current to plate B increases. And when we plot the current I_A - I_B against the potential E_A - E_B, we get the curves shown in Fig. 4. The portion of the curve shown as O P represents the negative resistance because the current increases as the potential decreases. It is this negative resistance that is responsible for the sustained oscillation. Fig. 5 shows the instantaneous potentials on the two plate segments during one complete cycle of oscillation.

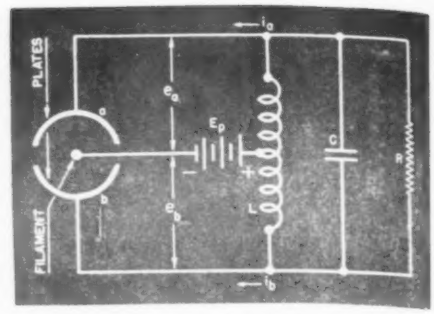
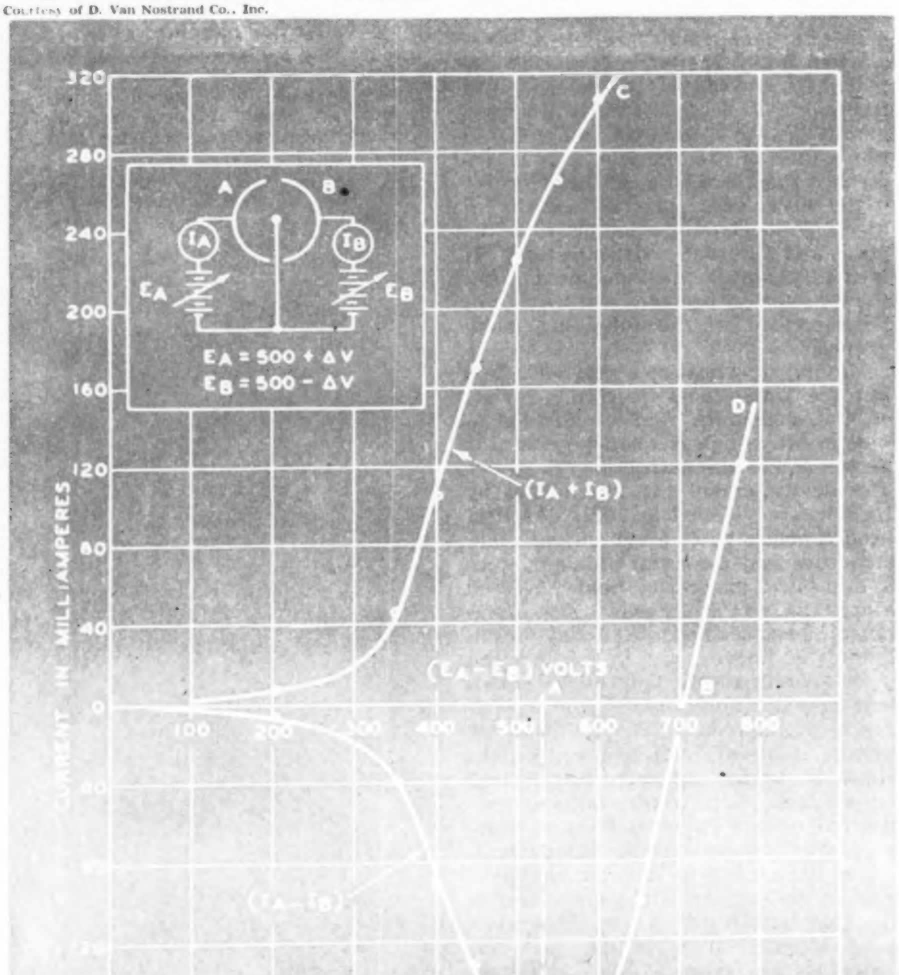


Fig. 3. Diagram of a split-anode magnetron tube. Note resemblance to the ordinary push-pull amplifier circuit.

Fig. 4. Static characteristics showing negative resistance of a two-segment magnetron.
Courtesy of D. Van Nostrand Co., Inc.



The reason for the peculiar behavior of the electrons in going to the plate of lower potential instead of to the other plate can be found only when the field due to the electric and magnetic forces in the tube are analyzed. It is due mostly to the magnetic force present, since removal of this field would force all the electrons to go to the plate of higher potential.

It must not be thought that the negative resistance is due to one plate alone. While it is true that the characteristic curves shown in Fig. 4 state that the voltage on one plate is increasing while on the second plate it is decreasing, it must be remembered that this is true only during one portion of the cycle. During the next portion of the cycle, the reverse is taking place and so now the opposite plate is exhibiting this negative-resistance characteristic. For those readers who may have trouble visualizing this process, reference to any ordinary push-pull amplifier will clear up this matter. Incidentally, these static curves can be used to calculate power output, efficiency and load resistance needed.

To visualize what the electrons actually do in the tube, reference is made to diagrams and a photograph published by Kilgore, which are shown in Fig. 6. In Fig. 6a, the potentials of the two plates are equal and the mag-

netic field is beyond the critical value. Here the electrons describe circular paths and as can be seen, none reach either one of the plates. In Fig. 6b and c the voltage of one plate has been increased while on the other it has been decreased. Now the electrons describe more or less complicated paths finally ending up at the plate of lowest potential. This point would not have been immediately obvious and is only due to the *strong* magnetic field. In Fig. 6d, a special gas was introduced which did not have any effect on the path of the electron, but nevertheless, made it visible. The photograph clearly substantiates the previous line of reasoning.

As the frequency of oscillation desired is raised, then the same troubles that one runs into with the ordinary negative-grid oscillators is encountered here. The main fault is again due to transit time. This can be overcome in part by either high plate voltage or small plate diameters. Included also, of course, is the much stronger magnetic field that must be used. As plate size is decreased, the allowable plate dissipation must be lowered and consequently, decreased power output. It is due to these limitations that again turned experimenters to using this device operated on the transit-time principle, or, to put it differently, to utilize transit time to advantage.

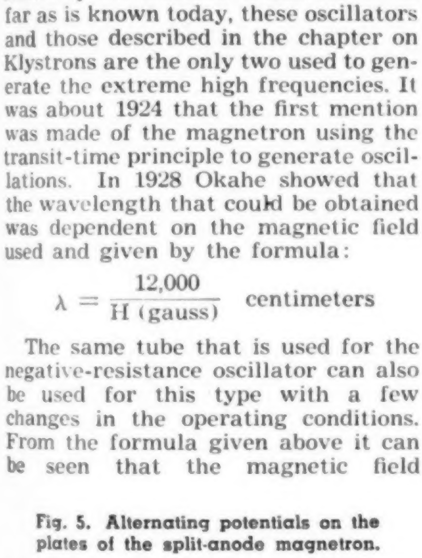
Transit-Time Magnetrons

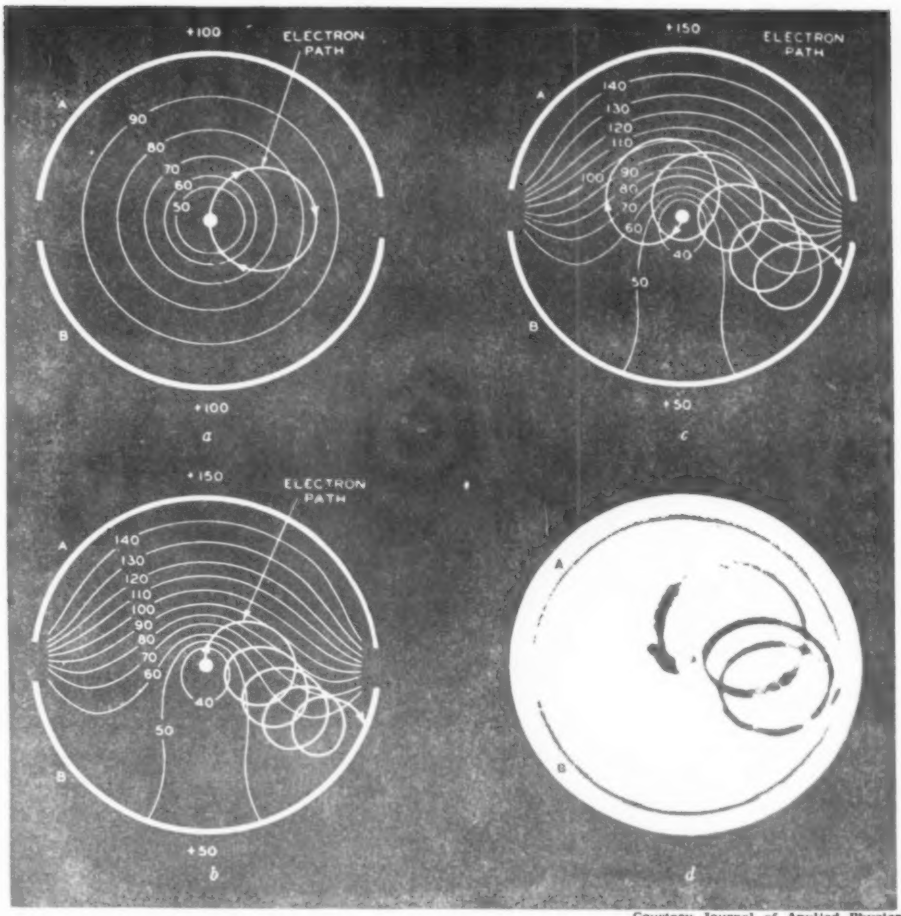
The other class of magnetrons that is used for the very short wavelengths operates at frequencies determined by the electron transit time. As far as is known today, these oscillators and those described in the chapter on Klystrons are the only two used to generate the extreme high frequencies. It was about 1924 that the first mention was made of the magnetron using the transit-time principle to generate oscillations. In 1928 Okahe showed that the wavelength that could be obtained was dependent on the magnetic field used and given by the formula:

$$\lambda = \frac{12{,}000}{H\ (\text{gauss})} \quad \text{centimeters}$$

The same tube that is used for the negative-resistance oscillator can also be used for this type with a few changes in the operating conditions. From the formula given above it can be seen that the magnetic field

Fig. 5. Alternating potentials on the plates of the split-anode magnetron.





Courtesy Journal of Applied Physics

Fig. 6. Typical electron paths in a two-segment magnetron showing how electrons arrive at the lower potential plate-half. (d) Photograph of ionized path of electrons in a gas-filled tube.

strength is critical in adjustment because the wavelength is dependent on it. At the same time this magnetic field should be adjusted near the critical value so that the electrons will not hit any of the anodes. Plate voltage will also have an effect on the radial motion of the electrons and must similarly be quite finely set at the correct value. In addition to all of the above, it was found that for optimum results the magnetic field should be slightly inclined to the tube axis. This inclination is never more than a few degrees.

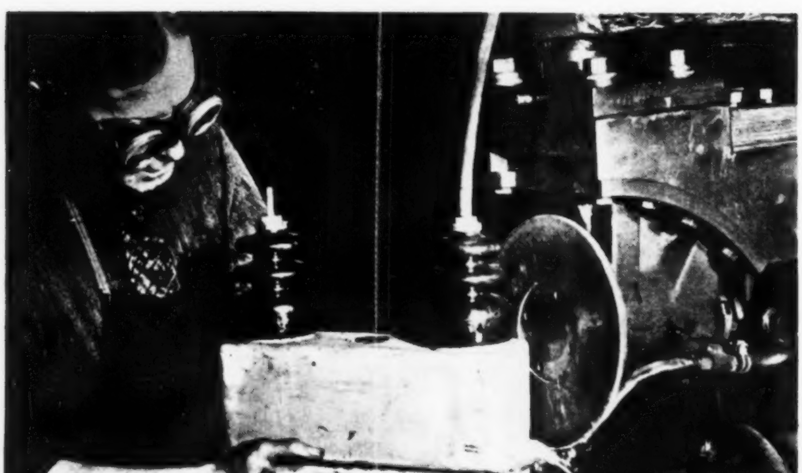
The mechanism of the transit-time magnetron is in many respects similar to the positive-grid oscillator previously described. However, in order to keep this discussion complete, the theory will be given here separately. In the operation of all magnetrons the magnetic field is adjusted so that the electrons just graze the plate as shown in Fig. 2. Now, suppose a small alternating voltage is superimposed onto the direct voltage already applied to the plate. Any electron leaving the cathode when the alternating voltage is going positive will be given a greater acceleration than had the a-c voltage been zero. Hence, this electron will probably hit the plate with the excess energy absorbed from the alternating voltage source. Since this electron absorbed energy it is imperative that it be removed as soon as possible. The object, as stated before, is for the alternating source of power to absorb energy, not lose it. This is the only way to sustain oscillations.

An electron that leaves the cathode a half cycle later will not approach as close to the plate as when the plate voltage was constant. This means that energy must have been given up by the electron to the source of alternating voltage since without the superimposed a-c fluctuations the electron ordinarily would have had enough energy at this point to keep on going. On its return trip the electron will not quite reach the cathode because now the plate is going positive and the attraction for the electron is greater than it ordinarily would be. The electron can continue to oscillate back and forth with decreasing amplitude and to deliver energy to the source of alternating voltage until it comes to rest at a point between the anode and the cathode, or is removed from the interelectrode space because of its sideward motion. It should be kept in mind throughout this entire discussion that the reason the electron moves to the plate and then swings back to the cathode is due entirely to the fact that there is a magnetic field present which tends to force the electron to move in a circular path. Without the magnetic field none of this action would be possible. Fig. 7a shows the motion of an electron that absorbs energy from the a-c source. Fig. 7b shows the path

(*Continued on page* 58)

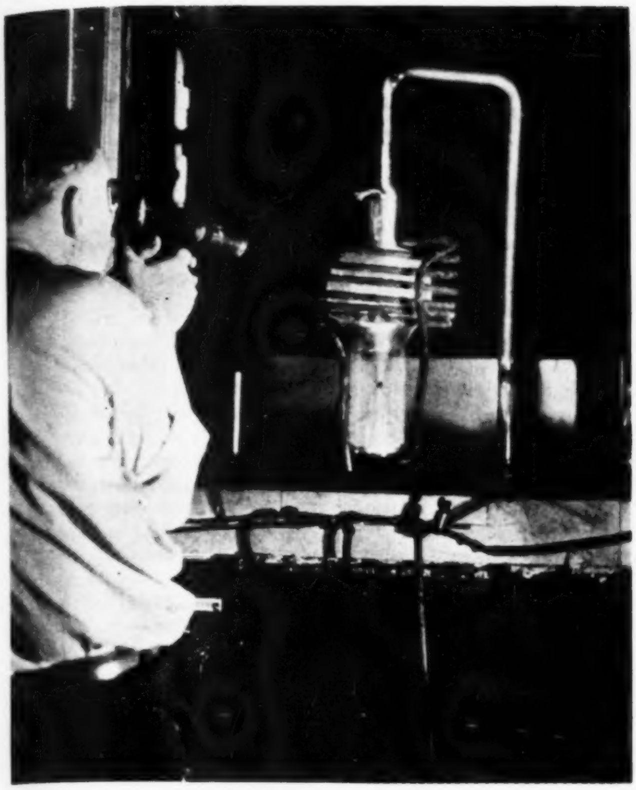
ELECTRONIC INDUSTRY

Checking mount mechanism of cathode-ray tubes in an air-conditioned, dustless room.



Operator is using a thyratron-controlled resistance welder to join two halves of a pyranol unit case.

AMERICAN industry's adaptability is again illustrated in its many uses of electronics. War needs have developed many new devices, inventions, and techniques, which already indicate wide application in the postwar era. Electronics will be found doing its job everywhere—in many industries. The steel industry, with its huge castings weighing many tons, will be assisted by the application of new and outstanding electronic X-ray machines. The plastic industry which will see great expansion in years to come, will be aided by pre-heating with electronic heat generators. Imagine the wonders of the modern home of tomorrow, with its electronic equipment, from the television set in the living room to the electronic oven in the kitchen. It is known that every possibility, indicated by wartime research, will be fully developed by industry for peacetime use.



Universally-used pyrometer in operation—measuring the temperatures of various elements of an electronic tube.

A thyratron half-cycle welding control panel used with bench units for spot welding vacuum-tube assemblies.

Electronic tubes serve as power switches for these resistance welders. Brackets of enamel stock are spot welded to housings by means of air-operated machines using an electronic contactor.

Manufacturers' Literature

Our readers are asked to write directly to the manufacturer for this literature. By mentioning RADIO NEWS and the issue and page, we are sure the reader will get fine service. Enclose the proper sum requested when it is indicated. This will prevent delay.

FACTS ABOUT PLASTICS

A new, twenty-four page, non-technical booklet covering all types of plastics, their uses, and general information on the plastics industry has just been released by *The Richardson Company,* Melrose Park, Illinois.

This illustrated book explains the host of properties which fit INSUROK and other plastics to the wide range of present and postwar uses. The limitations of plastics are also covered.

The two main groupings of plastics, Thermosetting and Thermoplastic, are described and illustrated in layman's language. Special sections are devoted to the forms of plastics, laminated and molded. The manufacturing and production processes of each are well illustrated.

The book is designed primarily for the non-technical man who may be serving on his company's postwar product committee and is desirous of obtaining a general knowledge of plastics and their applications. Copies are available only to those who write for them on their company letterhead to: *The Richardson Company,* Department 100, Melrose Park, Illinois.

TIMING DEVICES

An attractive new catalog covering various synchronous timing control mechanisms, has been released by *Haydon Mfg. Co., Inc.*

The broad range of special timing devices, tailor-made to the customer's requirements, includes improved designs of repeat and interval timers, time delay relays, contactors, interrupters, instrument clocks, elapsed time indicators, and other electrical apparatus for almost every conceivable timing application. Complete descriptions are given of each unit, and the catalog is profusely illustrated with photographs and dimensional diagrams of the devices.

Copies of this catalog may be had by writing directly to *Haydon Mfg. Co., Inc.,* Forestville, Connecticut.

RESISTANCE WELDING

An attractive 46-page booklet, consisting for the most part of published articles by *General Electric* engineers on the circuits and operation of electronic controls for resistance welding, has been published by the *General*

(*Continued on page* 109)

POSTWAR TELEVISION

By PHIL GLANZER

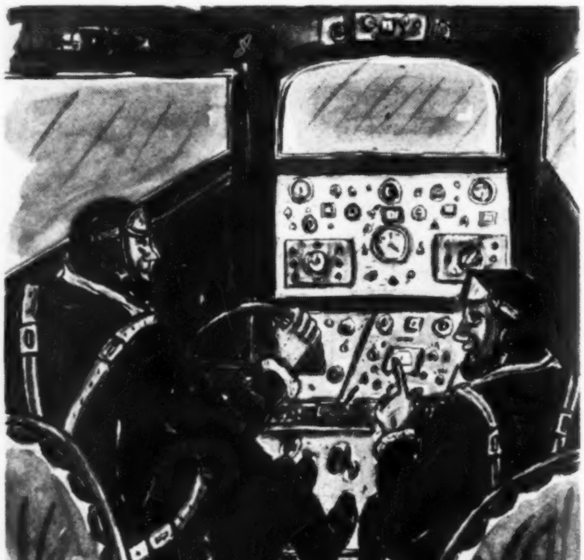
The future of television and the effect it will have on our economic conditions and social lives

ONCE again the world looks to science to supply it with a new industry, and, as the radio and motion pictures have proved possible, a new, vital force to aid in economic recovery and advancement. That invention which science is holding up its long sleeve is television.

The day of television is nearing. Before the war, England and Germany were both planning television on a large scale. A new television station was being built at Alexandria Palace in London.

In the United States, despite wartime conditions, active research and experimentation is proceeding behind the scenes with television programs. Canada, too, is participating with experimentation. A score or so of corporations and independent workers are hard at it on the North American continent—seeking to master the technique of sending pictures through the air or by wire. Thousands are experimenting with receiving apparatus and helping to perfect this startling new science—just as they "pushed" radio along.

But for the past few years we have heard much talk of postwar television —literally—in the air. We have heard wild promises and rash statements—that television would be "here as soon as the war is over," or "it would never be completely perfected."



"THIS complicated? Say, you should see my radio-servicing test bench back home."

These various contradictory statements have puzzled many—and occasional premature exhibitions of television sets have weakened the confidence of many in the final perfection of television. Many wonder as to just where television stands today—in the laboratory—and also wonder as to its possibility and proximity for use in the home and movie theater.

There are two problems facing television. One is technical—the other is financial. As engineers approach solutions to the technical questions, industrialists gasp at the cost of future television. As the technician gets ready to place television at the service of the public, the manufacturer and merchant are appalled at the apparent costs of an "image service."

There can be no gainsaying the fact that television has made huge advances—in the laboratory—in the last three years. Although few realize it, right on through the last depression, hundreds of thousands of dollars have been invested in the developing of television apparatus.

Large corporations, including the Radio Corporation of America, the American Telephone and Telegraph Co., Philco Radio and Television Co., and a host of independent companies have kept their scientific noses at the grindstone and are gradually perfecting television. The financial problems, which we will discuss later, are important—but can be, and will be, surmounted.

But let us understand that television will affect all of us quite directly. It will change our economic conditions, our social lives and even the educations of our children. Just as the general introduction of the auto and radio aided industry by furnishing thousands of jobs to mechanics, entertainers and salespeople, television will do the same.

Like the auto and the radio, it will bring the country closer to the city. It will remove the last vestige of country isolation. Just as the car has brought the country to the city and as radio has made Europe's news ours

(*Continued on page* 61)

PRACTICAL RADIO COURSE

by ALFRED A. GHIRARDI

Part 21. Continuing the study of inverse feedback and the benefits that may be realized from its use in amplifiers.

THE ratio E^1_o/E_s represents the effective over-all gain obtained when inverse feedback is employed (see Fig. 1) and is equal to:

$$\frac{E^1_o}{E_s} = \frac{A}{1 + \beta A}$$

This equation is a very important one for inverse feedback calculations. To illustrate its application, suppose that 25 per cent inverse feedback is applied to an amplifier whose voltage amplification is 100. The effective over-all gain will then drop to:

$$\frac{A}{1+\beta A} = \frac{100}{1 + (.25\times 100)} = 3.85$$

Examination of the gain equation reveals that as the feedback voltage, β, is made larger, the over-all gain of the amplifier system is reduced, and when β is made quite large compared with unity, the equation for the over-all gain reduces to:

$$\frac{E^1_o}{E_s} = \frac{A}{\beta A} = \frac{1}{\beta}$$

This represents the condition of affairs for true inverse feedback working. Expressed in words, this equation states that with large amounts of feedback the over-all gain of the system is *almost independent of A, the amplification of the amplifier proper.* This quite remarkable characteristic of feedback amplifiers results from the fact that when the feedback is large, the net signal voltage actually applied to the input grid represents a small difference between relatively larger signal and feedback voltages. Even a moderate change in the amplification A therefore produces a large change in the difference between the signal and feedback voltages, thereby altering the actual input voltage in a manner that tends to correct for the variation in amplification. It follows from this that if anything happens to change the amplification A (power supply voltage variations, or tube replacements, etc.) the change in output is much less in amplifiers where inverse feedback is employed than where it is not present.

In accordance with the foregoing, if, say 25% (¼) of the output voltage is fed back to the input, then the effective over-all gain is approximately $1/\frac{1}{4} = 4$, *provided that the product βA is large compared with unity.* This checks with the value obtained in the example stated earlier.

Actually, it is this proviso which constitutes one of the limitations of feedback amplifiers. Let us take, for example, an amplifier with a normal gain of 1,000. In this amplifier, for the product βA to be large compared with unity, β must be of the order of 0.01 to 0.005. If β is 0.01, however, the gain of the amplifier is only 100, so that we have obtained our inde-

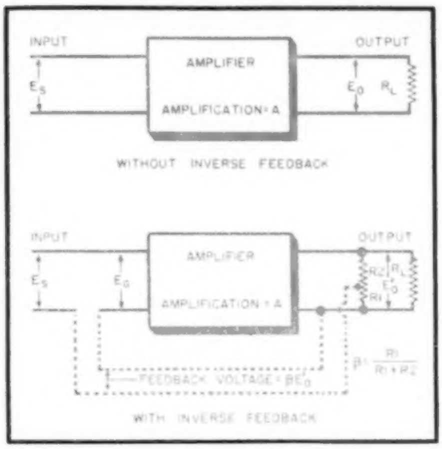


Fig. 1. Circuits used to show how inverse feedback is applied in amplifier circuits and to calculate over-all gain.

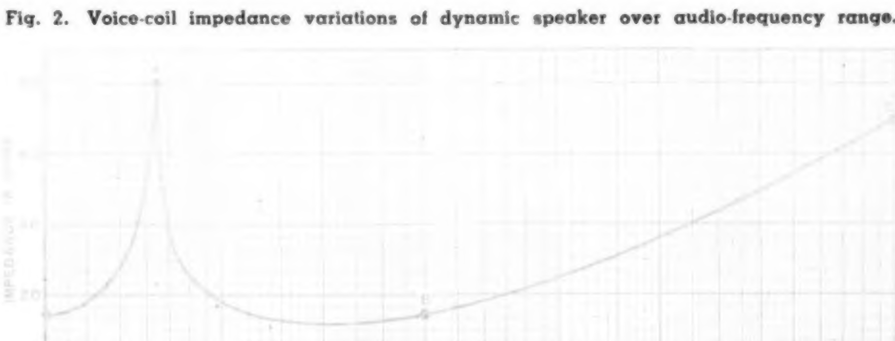
pendence of tube and circuit conditions at the expense of 9/10 of the gain. Of course, in most cases the input level to the stages comprising the feedback loop may be raised by the use of additional amplification to compensate for this.

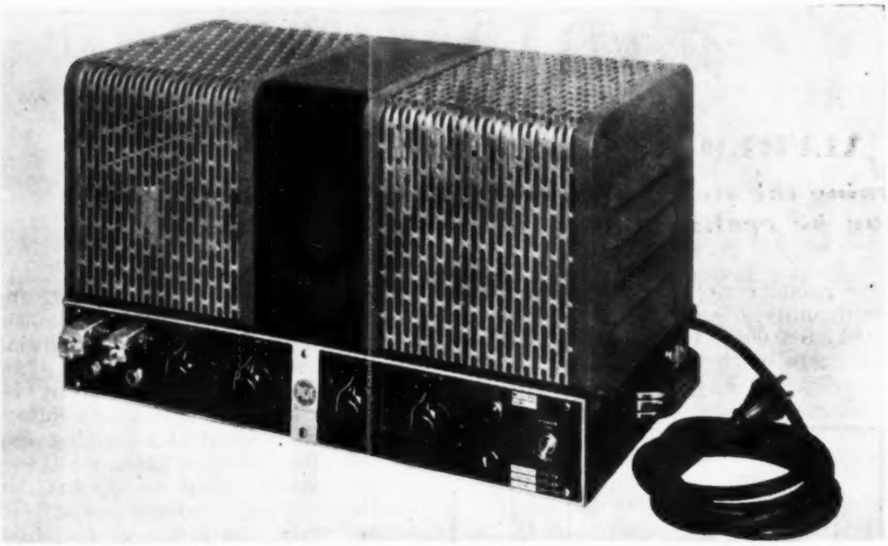
Effect of Inverse Feedback on Tube Plate Resistance

One of the most important effects produced by the use of inverse feedback voltage that is proportional to the output voltage, is the enormous *decrease* it causes in the apparent a.c. plate resistance, r_p, of the amplifier tube from which the feedback is derived. The internal plate resistance of the tube is not actually changed by the feedback. If the plate voltage rises, the voltage across the load decreases a corresponding amount, and the feedback decreases. This causes a positive change in grid potential, resulting in a decrease in the plate current. Now a plate-current *increase* as a result of a plate-voltage *decrease* is equivalent to saying that the effective internal plate resistance has *decreased.* Thus we say that the *inverse feedback reduces the a.c. internal plate resistance of the tube.* The effect is similar whether the feedback is taken to the grid of the final tube or to some earlier point in the amplifier, provided that the gain reduction factor is constant.

The new value of the internal plate resistance amounts approximately to dividing the plate resistance of the tube by $\mu\beta$. Since $\beta = \frac{R_1}{R_1 + R_2}$ (see Fig. 1), this expression reduces to $\frac{\mu R_1}{R_1 + R_2}$. Since μ for a typical power amplifier pentode may be of the order of about 600, if a ratio $R_1/(R_1 + R_2)$ equal to about 1/6 is used, the apparent plate resistance of the tube when feedback is used will be only about 1/100 of its normal value. The importance of being able to cause so great a reduction in the apparent plate resistance of a tube by applying such a nominal value of inverse feedback to it is evident. Simply by applying the proper amount of inverse feedback in this way to power amplifier stages that employ tetrode, pentode, or beam power tubes which normally have a very high plate resistance of the order of several hundred-thousand ohms, their plate resistance can be made very low, making them assume the desirable characteristics of low-mu triodes, yet retaining their moderate bias voltage requirements and a large part of their superior power sensitivity—all at the

Fig. 2. Voice-coil impedance variations of dynamic speaker over audio-frequency range.





25-watt amplifier incorporating inverse feedback to reduce hum and improve tonal quality.

cost of no more than a moderate reduction in the high gain. It is actually possible, in this way, to make the plate resistance even lower than that of a low-mu triode without feedback.

One of the direct benefits of the low effective plate resistance that can be obtained for pentode and beam power tubes lies in the fact that it provides a high degree of damping effective in reducing low-frequency "hangover" and "boominess" caused by the resonance effects present in the loudspeaker at certain frequencies, and which is so frequently present when pentode and beam-power type tubes are used in non-degenerative circuits. The property of low plate resistance is also of value when a tube forms the terminating resistance of a filter.

Although the apparent plate resistance of the output tube is greatly decreased by inverse feedback, the plate load required by it insofar as maximum power output is concerned is the same with or without degeneration.

To match the internal impedance of the output tube to the load resistance with which maximum power output is obtained, so that best performance will result, most pentodes should be degenerated so that the impedance (looking back into the tube) will be approximately 7000 ohms. Beam power tubes, such as the 6V6, should be degenerated so that their impedance will be approximately 5000 ohms. These values will be sufficiently low also to insure adequate damping of the speaker voice coil resonances.

The normally high plate resistance of pentode and beam power tubes is unsuitable from another important viewpoint—that of the amount of low-frequency distortion which may be tolerated. This low-frequency distortion is not due to the characteristics of the tubes (which remain unchanged regardless of frequency), but depends upon the *magnetizing* current in the output transformer. The magnetizing current is a distorted non-sinusoidal wave and this current, on flowing through the high plate resistance of the tube, develops a non-sinusoidal voltage drop across the tube which, when subtracted from the input signal, results in a distorted wave across the output. Unfortunately, it has become a practice to measure most amplifiers for distortion at 400 c.p.s where the magnetized current is practically negligible. It is not uncommon to find beam power amplifiers without inverse feedback which have only 25 per cent of the rated power at 40 or 50 cycles. This low-frequency distortion is particularly objectionable since all harmonics fall within the audible range. Inverse feedback effectively reduces the plate resistance so that the distorted voltage drop caused by the magnetizing current is exceedingly small, with the result that there is very little distortion across the output circuit. With a poor output transformer it is quite possible for the distortion to be as high as 30 per cent at 40 cycles without inverse feedback.

How Inverse Feedback Improves the Output Regulation

Another beneficial result of the decrease in the apparent a.c. plate resistance of the tube by inverse feedback action is that it automatically compensates for changes and wide variations in output load; that is, the output voltage from the tube is made relatively independent of the load impedance. This is easily explained. If we imagine an amplifier to be feeding a certain load resistance, and then that load resistance to be reduced through any cause, the output voltage will tend to drop. But if inverse feedback is in use, any such reduction in output voltage causes a proportional reduction in feedback and a rise in over-all gain that raises the output voltage and partly neutralizes the tendency to drop. Similarly, if the load resistance is increased, or the load is removed altogether, the output voltage tends to rise. The increased degeneration voltage fed back to the input acts to diminish the effective input signal, resulting in a limited rise in power level. A system in which the output voltage changes very little when the load resistance varies appreciably is one in which the internal resistance is low. The inverse feedback circuit tends to give this sort of characteristic.

Improved Output Regulation Reduces Distortion Caused by Varying Speaker Impedance

This improvement in output regulation serves to reduce another source of harmonic distortion and frequency distortion in a pentode or beam power output tube that feeds the voice coil of a loudspeaker. As was explained and illustrated in Lesson 19 in the November, 1943 issue of RADIO NEWS, the inductance of the voice coil causes its impedance to rise at the higher audio frequencies. Consequently, the impedance of a loudspeaker (including its output transformer) is not constant for all audio frequencies, and it presents a variable-impedance load to the output tube in whose plate circuit it is connected. Furthermore, one or more resonance peaks are usually present, at whose frequencies rather abrupt impedance increases occur. The variation of the impedance of the voice coil of a typical loudspeaker over the audio-frequency spectrum is illustrated in Fig. 2. The sharp rise at point *A* is caused by a resonance condition. The voice coil impedance varies between about 17 and 80 ohms. Naturally the output transformer will reflect this wide impedance variation into the plate circuit of the power tube. This wide variation of plate load will produce, if not corrected, considerable accentuation of the higher *frequencies* (and the frequencies around the resonance point) which is quite objectionable in the usual pentode amplifier. It may also cause *harmonic* distortion. Both forms of distortion may be corrected either by a simple corrective resistance-capacitance filter (see Part 19 of this Course) connected across the output transformer primary (with a corresponding loss of high audio-frequency power dissipated in the resistor), or by the use of inverse feedback. Any distortion due to *resonance* effects in the speaker *will not* be corrected by the filter. Inverse feedback must be employed to accomplish that.

Improved Output Regulation Reduces Necessity for Close Speaker Impedance Matching

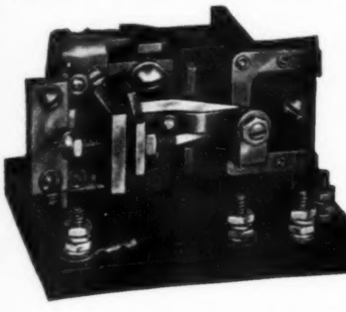
One of the most troublesome problems in P-A installations is that of loudspeaker impedance matching. First, because the speaker voice coil is inductive, no speaker has a constant impedance at all frequencies. Therefore, the impedance reflected to the primary of the output transformer will also change, causing variations in the signal voltage developed across

(*Continued on page* 63)

WHAT'S NEW IN RADIO

RELAY FOR COIL CURRENTS

A new *Struthers-Dunn* Relay, Type 79XAX, is designed for a variety of electronic circuit applications calling for a highly sensitive unit having snap-action contacts. Contact pressure of this relay remains constant despite slow variations in the coil current in which it is connected. Then, when the coil current reaches a certain point, the contacts operate with a positive snap action.

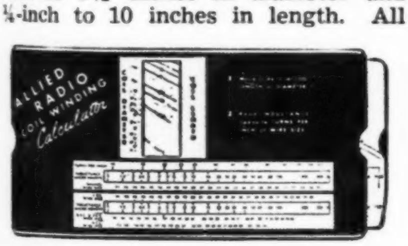


The relay operates on as little as 10 milliwatts in its coil circuit, and is recommended for dozens of highly sensitive vacuum tube applications, as well as in detecting overloads at low current levels. Its greatest field of usefulness lies in applications where current varies slowly between various limits, rather than quickly from 0 to rated value.

Details will gladly be supplied by *Struthers-Dunn, Inc.*, 1321 Arch St., Philadelphia, Pa. Please ask regarding Relay Type 79XAX.

COIL-WINDING CALCULATOR

Allied Radio Corporation, Chicago, announces the release of a new slide-rule type rapid calculator, permitting quick and accurate determination of inductance, capacitance, and frequency components of series or parallel tuned RF circuits as well as inductance, turns-per-inch, wire type, wire size, coil diameter and coil length for single layer-wound solenoid type RF coils. All values, in either case, are found with a single setting of the slide and are accurate to within approximately 1% for coils ranging from ½-inch to 5½ inches in diameter and ¼-inch to 10 inches in length. All possible combinations within these limits are shown.



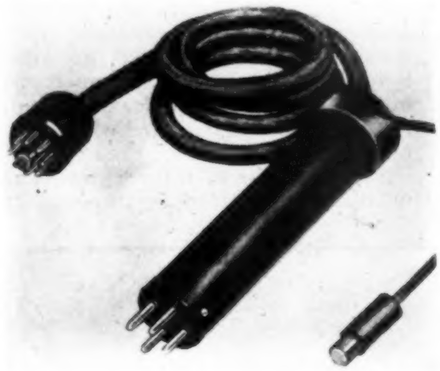
Wire types and sizes include 11 to 35-gauge plain enamel, 11 to 36-gauge S.S.C., D.S.C., and S.C.C., and 12 to 36-gauge D.C.C. The rule is also engineered to indicate: turns-per-inch from 10 to 160; inductance from 0.1 to 15 microhenries; capacitance from 3 to 1,000 micromicrofarads; frequencies from 400 kilocycles to 150 megacycles with equivalent wavelengths in meters.

The speed and accuracy with which these factors can be related provide the engineer, maintenance man, service man, amateur, student, instructor, and experimenter with an invaluable tool. Priced at 25c each. Address correspondence to the *Allied Radio Corporation,* 833 West Jackson Boulevard, Chicago 7, Illinois.

CML PRODUCTION PLUGS

Developed for use with the Rotobridge in testing electronic equipment, *CML* production plugs are now available generally for use by electrical manufacturers. In their application to the Rotobridge, these plugs have had to be sturdy in construction in all respects, in order to withstand constant usage for many thousands of operations.

CML production plugs are 5 inches long and 1¼ inches in diameter, so that the handle will project above the average IF transformer, condenser, making it readily accessible. The Production Plugs are made with a heavy steel barrel and are filled with a wooden handle to permit ready removal from socket. All pins are case hardened steel to assure long life, yet may be replaced when worn or broken. In both the octal and loktal plugs, center key extends through in form of a threaded rod to permit cable to be fastened firmly in position without strain on pin connections. A flat head machine screw serves same purpose in the other plugs. In addition to the octal and loktal types, these plugs are available in 4, 5, 6 and 7 pin models.



Descriptive bulletin is available from *Communication Measurements Laboratory,* 116 Greenwich Street, N. Y.

INSULATION-RESISTANCE METER

A new electronic insulation-resistance meter for measuring the resistance of insulation in apparatus during the manufacturing process, thus revealing imperfections before the product leaves the factory, has been announced by the Special Products Division of the *General Electric Company.* The instrument is also desirable for checking the condition of insulation of apparatus in service, and for use in the laboratory for rapidly testing a wide range of production or experimental samples of insulating material.

The instrument consists of a conventional electronic rectifier, a Thyrite bridge circuit, and an electronic-tube voltmeter. It is available in two types. One type has a scale calibrated from 1 to 50 megohms and measures resistance at 500 volts d.c., the other type has a 0 to 20,000 megohm total range and measures resistance over four different resistance intervals—from 0-5 megohms at 0-250 volts d.c. and 5-200, 50-2000 and 500-20,000 megohms at 500 volts d.c. Any range may be quickly selected by a panel-mounted rotary switch.

In the operation of the insulation-resistance meter, which can be used wherever 115-volt, 60-cycle current is available, the measuring leads from the instrument are connected to the apparatus or material to be tested. The scale-range selector switch is turned to the lowest range, and the power switch is turned on. If necessary, the selector switch is turned to successively higher ranges until the pointer of the illuminated scale is in the center portion of the scale. The resistance of the material under test is read directly in megohms. The test voltage is regulated to 500 volts d.c. by the Thyrite bridge, even though the 60-cycle line voltage is fluctuating.

(*Continued on page* 108)

THE SAGA OF THE VACUUM TUBE

By GERALD F. J. TYNE
Research Engineer, N. Y.

Part 10. Covering the evolution of the vacuum tube through the years 1914 to 1918, as a result of the research work done by Western Electric.

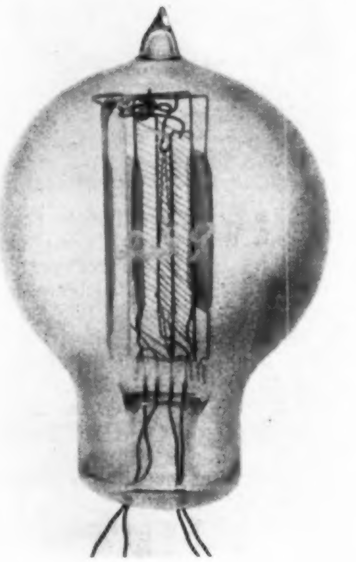


Fig. 92.

THUS far we have considered but one type of Western Electric tube. It has been treated in considerable detail, because of the evolutionary steps through which it passed. These steps show the results which may be attained through painstaking research and careful engineering with but one objective—to produce the most economical and reliable device to fulfill a given function, when operated under expert care and carefully controlled conditions.

Other tubes were evolved in the laboratories and manufacturing plants of the Western Electric Company during the period covered in the preceding articles. Some were for use in the telephone plant, some for the Armed Services of the U. S. Government, and others for divers applications which arose as time went on and wider vistas opened up.

Many of these went through developmental steps paralleling those of the 101 type and will be treated but briefly in what follows. One of the best known of these other tubes is the famous "V" tube. This was probably so called because it was intended for use as a "voltage" amplifier. It was first known as the type "VM"—V for *voltage* and M for *mounted*—but the "M" was soon dropped and it became known as the "V" tube.

The earliest vacuum-tube repeaters, as has been previously stated, used "L" tubes and were single-stage affairs. When the need for higher amplifications than could be obtained in these arrangements arose, two-stage repeaters were developed, and the "V" tube was used in the first stage to provide "voltage" amplification. Its plate-to-filament impedance was too high to permit it to be worked successfully as an output tube, however, and the second stage was an "L" tube with its lower output impedance.

The first experimental "V" tubes

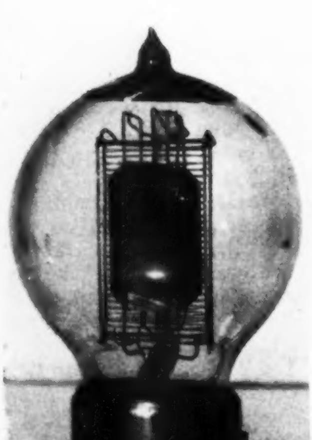


Fig. 93.

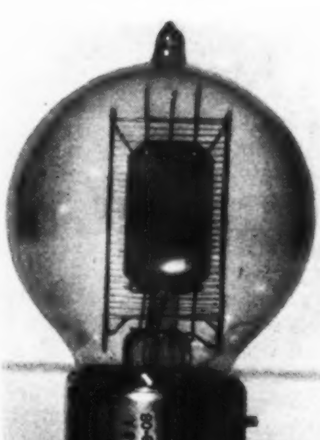


Fig. 94.

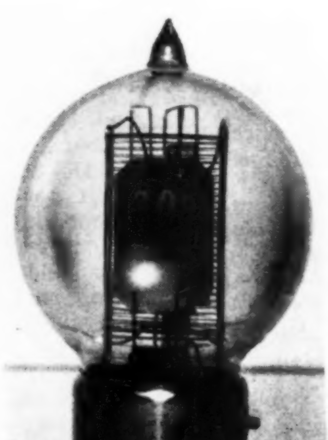


Fig. 95.

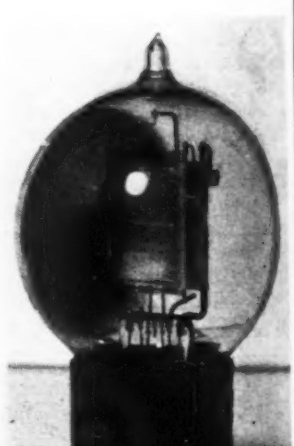


Fig. 96.

Fig. 97.

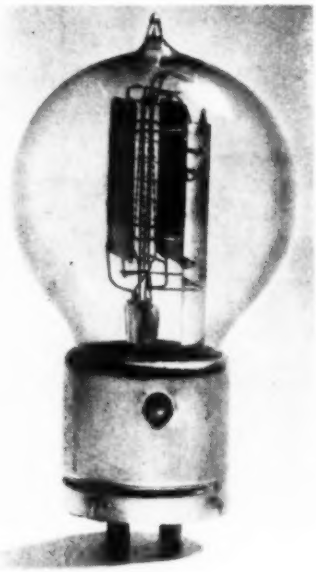


Fig. 98.

Fig. 99.

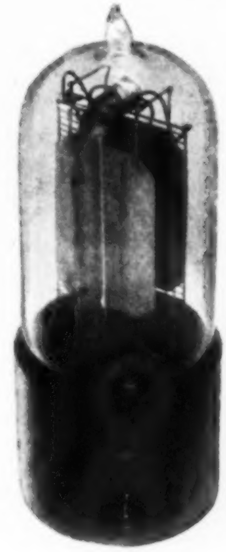


Fig. 100.

were made about the middle of 1914 and the first commercial product appeared early in 1915. Fig. 92 shows one of the earlier tubes before basing.

The "V" tube used the characteristic Western Electric "ladder type" grid and had 31 laterals on each side. The grids were considerably larger in area than the plates, and the filament was Λ shaped. The spacing between grids was about ⅛ inch and between plates about ½ inch. The base used was the same machined brass base used on the "L" tube which has been previously described.

Like the "L" tube, the first of the "V" tubes probably carried no patent markings. Beginning late in 1915 patent markings were applied in a manner similar to that of the "L" tube of that time. In 1916 the code designation "102A Telephone Repeater Element" was assigned to the "V" tube. This was later changed to that of "102A Repeater Bulb."

It is not our purpose to go into further detail concerning the progressive changes made in the "V" tube. However, for the benefit of tube collectors Fig. 93 shows one of the variants of the 102A.

Up to the end of 1918 all of the "V" tubes and some of the other tubes made by the Western Electric Company had been manufactured in the shops of the Engineering Department of the Company in New York. This was done because of the need for close engineering supervision in the early manufacture of a new device. By the end of 1918 progress was considered sufficient to permit their manufacture in the regular factory, and accordingly, production of some of them, among which was the 102A, was begun at the Hawthorne plant of the Company in Chicago.

All of the early Western Electric tubes had a serial number etched or sandblasted on the bulb. In order to distinguish between tubes made in New York and in Hawthorne the tele-

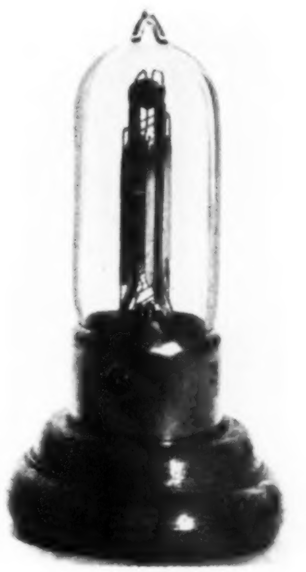


Fig. 101

Fig. 102.

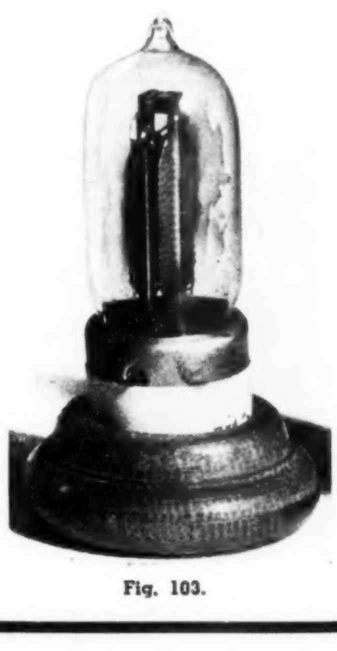


Fig. 103.

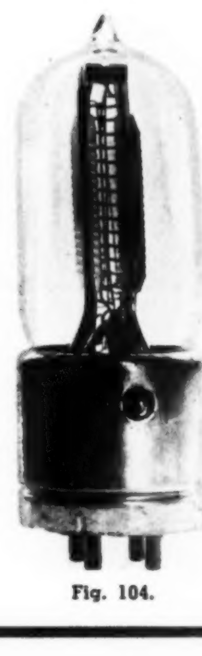


Fig. 104.

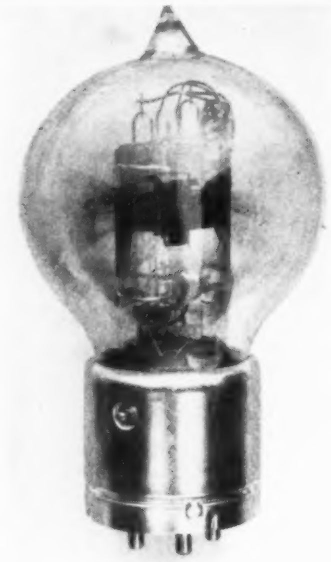


Fig. 105.

Fig. 106.

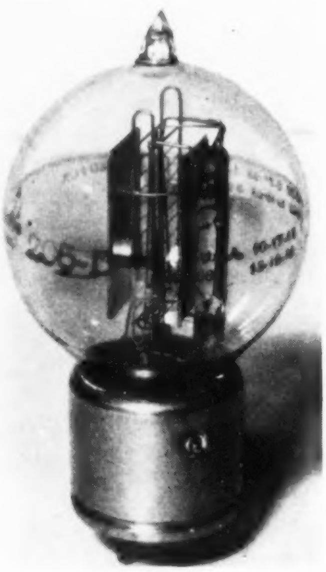


Fig. 107.

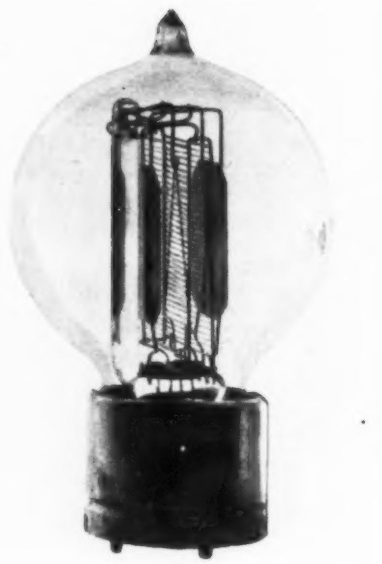


Fig. 108.

phone repeater type tubes made at Hawthorne had the letter "H" appended to the serial number. When production became great enough so that the number of digits in the serial number increased beyond five, the designation letter was changed to "A" and the numbering repeated. The tubes made at New York had no letter included in the serial designation.

There were also some minor details of construction in which tubes made at Hawthorne differed from those made at New York. One of these was in the positioning of the laterals of the grid. In the tubes made at New York the grid laterals were welded to the vertical support wires on the outside of the frame; that is, the side away from the filament. Tubes made at Hawthorne had the laterals on the side of the frame nearer the filament.

The construction of the 102A Repeater Bulb was similar to that of the 101B in that the elements were supported by a glass arbor welded to the edge of the press. Early in 1922 the 102A was replaced by the 102D which had an improved filament, operating at the same filament current as the 101D. The construction was soon changed so that the arbor was attached to the stem below the press, in a manner analagous to that of the later type 101B and the 101D. The single Λ filament was retained since the normal plate current of the 102 types was much lower than that of the 101 types and the electron emission from the smaller surface was adequate.

From this time on the changes in the 102 series, such as location and type of markings, substitution of molded for metal base shells, etc., in general followed those of the 101 series and will not be detailed here. Again for the benefit of the tube collector photographs of some of the variants

(Continued on page 90)

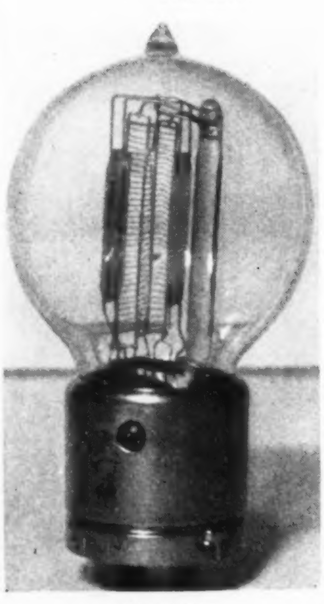


Fig. 109.

Fig. 110.

Fig. 111.

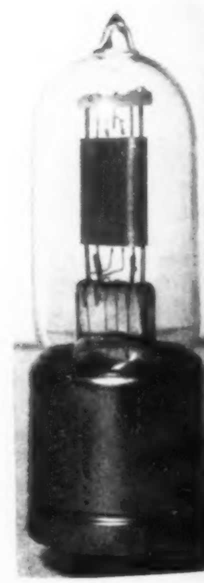


Fig. 112.

Maximum Performance
Under ALL Conditions

You can always expect the fullest measure of performance from Ohmite Rheostats and Resistors. *Because,* they're made *extra sturdy* . . to provide accurate resistance-control day after day under the most critical operating conditions. This dependability has been *time-proved* in electronic and electrical equipment in all types of aircraft and in the tools of production. Ohmite Engineers are glad to assist you on any resistance problem.

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Two-Way Radio
(*Continued from page* 25)

functioning with frequency modulation in conjunction with other phenomena. In fact the Association of American Railroads and important member railroads have already investigated this plan and are receptive to proposals for postwar utilization with moving trains.

Generally speaking, the postwar 2-way radio set will have clarity incomparable with anything heretofore known. It will have a signal strength within the horizon which will be much greater than anything thus far achieved with mobile units. It will function for the full horizon and because of the many integrated advantages and efficiencies incorporated in its design, it will reach even into the adjacent horizon. Since the microwave band now feasible to utilize contains already 100 times more channel space in terms of kilocycles than that utilized by all existing radio stations in the world, and what is even more important . . . the fact that these frequencies can be used again every other horizon, means that postwar 2-way radio communication faces a very great future.

How great is this future? It is a future of 5,000,000 potential sets within the next 5 to 10 years. It is a future where 30,000 jobs will be created in connection with its manufacture, installation, maintenance and utilization. What are these new applications that will increase the market 100 times? Here are a few utilizations that experienced radio engineers claim will be provided.

1. 2-way communication between fixed and moving points on the railroads of the United States as well as between the trains themselves and for front-to-rear communication on the same train. One group is now quoting a blanket rate of $30 per mile of route to railroads for complete 2-way coverage.

2. Taxicab fleet dispatching for communication between dispatching point and taxicabs as well as between taxicabs themselves. It will avoid the necessity of aimless cruising in congested city streets. A taxicab will discharge his passenger and wait at that point for another call. If someone desires a cab, a telephone call to

TABLE I

Advantages of postwar two-way FM radio sets over the prewar AM type.

1. Very low power. One system of great promise coming out for postwar railroads and taxicabs has an output power of 1/100th of a watt output. Likewise it has a very small power consumption.

2. Functions on the microwave band using frequencies between 100 and 10,000 megacycles with emphasis above 2,000 megacycles.

3. Utilizes frequency modulation with a simplified and very remotely related offshoot of the Klystron Oscillator.

4. The transmitter component utilizes microphone, input transformer and a special oscillator of a dependable type. The receiver still will resemble the present day FM 2-way receiver but will use miniature tubes having higher amplification factors and lower interelectrode capacitances.

5. It will use a wave-guide antenna with radiation as desired.

6. The antenna will be focused in almost every case. It will be controllable as to width and elevation of the beam and it can be sent out in conic or rectangular fashion to occupy a limited sector. For railroads it will be directed down the track with gain as high as 2,000 if desired. Directivity is simplified since a half wave may represent only an inch in length on microwaves. This compares with 12 to 18 feet in the present ultra-high frequency police band which makes direction radiation difficult because of dimensions and physical considerations.

7. Equipment will be compact, light weight and inconspicuous.

8. Reception will be clearer than anything heretofore available and the receiver will be quiet when no signal is coming through.

9. It will be much less costly than existing sets and will justify replacing existing equipment.

10. It will have hundreds of times more signal strength than any existing 2-way mobile set. Its gain can be integrated because of the following:

Initial power 1/100th of a watt.

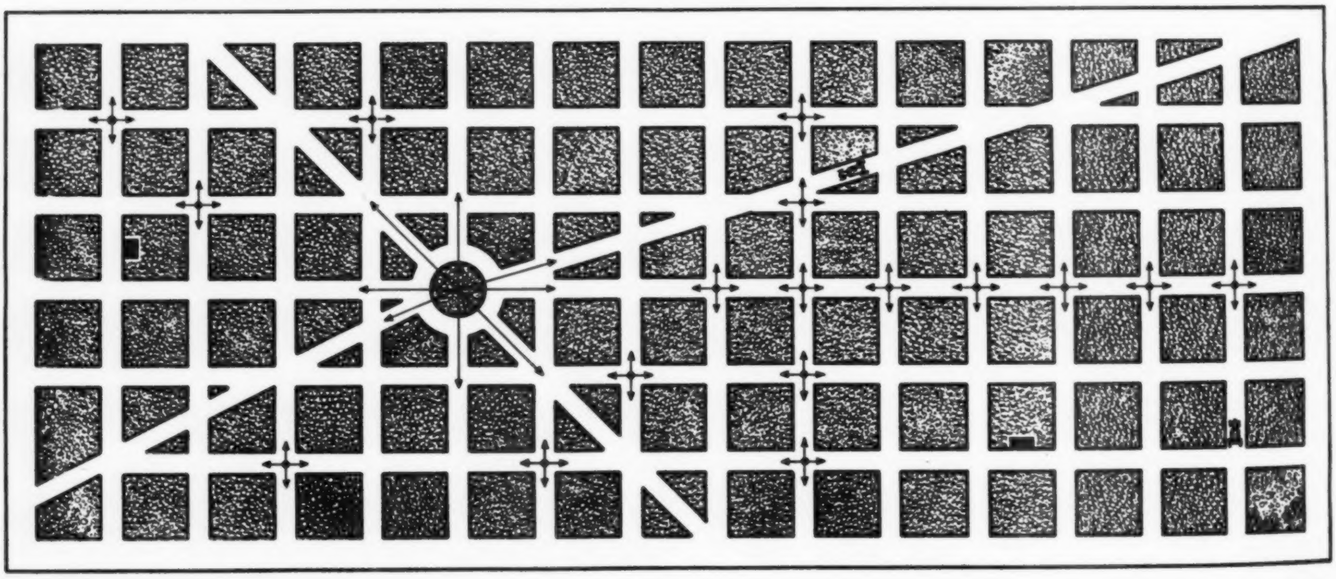
Advantage of 3 to 1 by use of FM over AM.

Deviation ratio of 100 to 1 utilizing more of receiver bandpass.

Receiver operates above noise further than AM. 10 to 1 or more.

Focussed antenna possible with gain of 100 to 2,000. times. This integrates to $1/100 \times 3 \times 100 \times 10 \times (100 \text{ to } 2{,}000) = 3{,}000 \text{ to } 60{,}000$ *watts as compared to present day AM types on the ultra-high frequency band used in police radio, using 10 or 15 watts.*

Fig. 1 Contemplated two-way microwave telephone system for a typical city area. Provides communications between headquarters to mobile units, mobile units back to headquarters, mobile units to other mobile units, and headquarters to headquarters. Points with arrows are unattended 2500 megacycles automatic relay stations.



the dispatching office will dispatch the nearest cab in the customer's vicinity. Frequently the cab may be within a block of the call and furnish excellent service, arriving almost at the time the phone call is completed.

3. Trucks, buses, delivery vehicles and even passenger cars can be contacted or they in turn can communicate while in motion to change their route or report any occurrence.

One group has estimated that it can provide full coverage on every street and avenue on the island of Manhattan, New York City for a total of $30,-000 in the microwave band. It proposes to do it by providing an automatic relay station on every street and avenue in the city except at a rotary circle where one station can cover all streets and avenues radiating from there. Fig. 1 illustrates the kind of system they have in mind.

Amplitude modulation is definitely out postwar unless the application is so local and unimportant that any degree of efficiency, regardless how small, will suffice. This will be so because it is desired to obtain all the advantages of deviation ratios, frequency swing, receiver's inherent bandpass on very high frequencies, signal to noise ratio, freedom from interference and maximum receiver sensitivity.

The postwar set will be inconspicuous. It requires no tell-tale or vulnerable fishpole antenna to strike trees or obstructions. Its size will be so small as not to be recognized and it can fit in plenty of available spaces. Its battery consumption will be about one-fifth that used today by 2-way mobile radio equipment. The postwar set, because of cost, standardization and simplicity, will be such that present day radio systems will not find the cost prohibitive to change over and abandon the ultra-high frequency band. Neither will the cost prohibit using a large number of automatic relay stations to cover any required area and set of conditions. Users of such equipment will not require their own servicing personnel and service depots or parts. Tentative quotations are $200 per station completely installed with perpetual maintenance and parts replacement for $50 per year per station. Equipment will be removable or replaceable with old units replaced by overhauled units in a matter of minutes and returned to manufacturer's service depot for overhaul under contract.

Table I indicates how the postwar 2-way radio set, while having an actual power of 1/100th to 1/10th of a watt, will be as efficient as an AM set of 10,000 watts based on prewar standards.

In a forthcoming issue of this magazine, the writer will present an article on "Ultra-High Frequencies versus Microwaves." In connection with this article, readers are also referred to page 42 of December, 1943 RADIO NEWS entitled "Am vs. FM in Two-Way Radio."

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Theory of U.H.F.

(Continued from page 43)

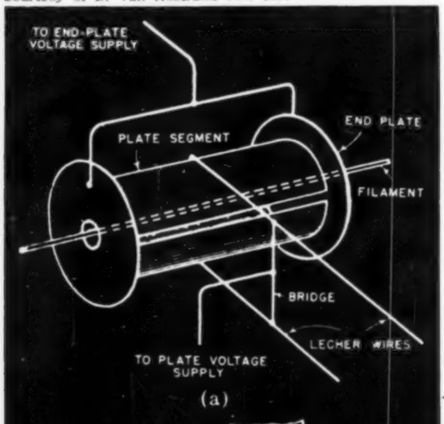
of the same electron giving up energy, causing oscillation.

Returning now to the mechanism of the tube it can be seen that all electrons leaving the cathode when the plate voltage is increasing will absorb energy and probably be captured by the plate, whereas those electrons that are emitted by the cathode when the plate voltage is decreasing will not reach the plate, but rather oscillate in the manner previously described. Since the same number of electrons are emitted when the alternating plate voltage is going positive as when it is going in the opposite direction, and since the energy-absorbing electrons are removed as soon as they strike the plate while the energy-losing electrons oscillate for several cycles, the source of alternating voltage gains energy. This condition is precisely the same as in the positive grid or Barkhausen-Kurz generator.

At first thought, it might be desired that the energy-losing electrons be kept in the interelectrode space as long as possible. However, it has been found that this is not so. The reason is due to the changing phase relation of the induced voltage. With each successive cycle of oscillation, the electron has less and less energy available and so the distance through which it moves decreases and the transit time goes down. This is equivalent to an advance in phase of the electron oscillation relative to the alternating plate voltage. If this shift continues, not only will less and less energy be given up by the electron, but it may even start absorbing energy. It has been found that the magnetic field must be slightly tilted (not more than a few degrees) with respect to the tube axis

Fig. 8. (a) Structure of end plate magnetron. (b) Method of applying magnetic field.

Courtesy of D. Van Nostrand Co., Inc.



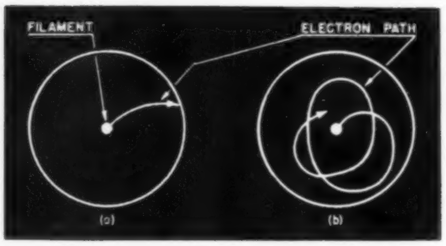


Fig. 7. (a) Electron absorbing energy from alternating power source. (b) Electron giving up energy causing oscillation.

in order to obtain best results. This tilting action imparts a velocity to the electrons parallel to the filament and after several cycles in the interelectrode space the electrons strike the plate and are removed. The angle is quite critical and must be changed with plate voltage. The problem, of course, is obvious. The electrons should be allowed to remain in the interelectrode space until all the energy that can be obsorbed has been absorbed, then they should be quickly removed. This explains the tilting action. One bad result of this tilting is the heating of the glass envelope of the tube itself. If allowed to continue for any length of time, the glass will melt with the eventual destruction of the seal.

Linder has advanced a solution of the tilting process that is used most widely in all the magnetrons. He found that by putting in end plates, shown in Fig. 8, and applying a small positive voltage to them, that the tube no longer has to be tilted for the electrons to be removed. It has also been found that the efficiency has increased due to these end plates.

The theory of the mechanism of transit-time magnetrons holds essentially whether the anode is a one-piece cylindrical plate, a two-segment plate or even a four-segment plate. It is true that there are slight differences in the electron motion in these various types of magnetrons, but these need not concern us here since, as mentioned, the explanation is essentially the same.

For optimum output the transit-time magnetron requires a smaller filament emission than the negative-resistance tube and is far more critical to changes in this emission. This is probably due to the effect these changes have on the space charge in the tube itself. It is customary to interpose a filament-current stabilizer between the source of power and the filament. Another source of trouble is in keeping the magnetic field strength constant, since the formula previously given for wavelength is directly connected to this factor. The difficulty is avoided by using electromagnets at high voltage and low current. The schematic diagram for a power supply given in the chapter on the Klystron tube can also be used here.

The useful frequency range of any one magnetron tube is approximately 2 to 1. In order to cover a wide range of frequencies many tubes of varying sizes must be used. It was found that the optimum anode diameter should be 1/20 the wavelength desired. Of interest to engineers and circuit designers is the fact that the transit-time magnetron can be operated with a much lower load impedence than the negative-resistance magnetron and so can be operated with tuning elements of a lower Q. One explanation of this observation states that it is due to the fact that a small amount of potential on the plate segments can cause large circulating currents which in the ordinary tube would require a much greater voltage. Oscillations have been known to exist in tuning circuits with an impedence as low as 100 ohms, which is very helpful in attaining the high frequencies.

In looking up the literature on the magnetron tube, one will often find the statement that a smaller magnetic field is needed in the transit-time tube than in the negative-resistance version. That this is true can be seen from the following line of reasoning. For the negative-resistance type magnetron the efficiency begins to fall off when the transit time of the electrons is greater than about 1/10 of the period of oscillation. The magnetic field must therefore be correspondingly greater in order for the electron to complete the cycle that much sooner. In the transit-time oscillator, the allowable electron transit time is ½ of the oscillation period. Hence, not so great a magnetic field of force is required, the difference being in the ratio of about five to one. This result is a considerable saving since the difficulty in constructing a suitable electro-magnet rises rapidly as the number of uniform flux lines required increases.

The subject of modulation of the magnetron has not been freely settled to the satisfaction of all concerned. It might be stated that the method probably adopted will tend more toward frequency modulation than amplitude modulation.

One more mention should be made of the effect known as "filament bombardment" before closing the chapter on magnetrons. This effect has been noted by many experimenters and contributes much toward the limiting of the usefulness of this type of oscillator. When attempts are made to obtain large amounts of power, it is found that the filament of the tube begins to heat up and eventually disintegrate. The reason has been attributed to the bombardment of the filament by electrons or ions containing considerable amounts of excess energy. One means used to overcome this lies in shielding the filament to some extent while another method proposed is to attempt a filament-stabilization method. As stated, this defect shows up when the power requirements are raised, but it is believed that the newer type of magnetrons have already eliminated this difficulty.

In summarizing the contents of this chapter it should be pointed out that in the negative-resistance magnetron

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WANTED IMMEDIATELY—3 dynamic mikes with stands and cables (Amer. D4T, D8T, D9T, VR2T; Turner 99, U9S; Amperite PG, etc.); 2 induction phono-motors and one 3 in. or 4 in. sq. 0-1 ma. meter. Cash. David Williams, P.O. Box 281, Pleasanton, Calif.

WANTED—Good comb. tube tester & set analyzer such as Triplett No. 1183. Name price. Philip P. Goldstein, 288 Ave. P., Brooklyn 4, N. Y.

WANTED—Pocket AC-DC V-O-M. Describe fully for quick reply. H. C. Dexter, Box 262, Princeton, N. J.

WANTED—Tube tester, also sig. generator. Describe fully. Philip Kirkpatrick, Greenwood Mt., Maine.

FOR SALE—Two type 78 tubes with shields, 55c ea.; No. 41 at 47c; 6A7 at 56c; 6B7 at 70c. Want used radios & parts. C. Brown, 502 N. High, El Dorado, Kans.

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FOR SALE—12-Watt amplifier—P.P. 2A3, output transformer 8016 ohms, heavy-duty trans. and chokes, compl. with tubes, $30. Frank W. Jones, Gabbs, Nevada.

EQUIPMENT WANTED—Tube testers: Jackson No. 636; Supreme 589-P; Triplett 1612. Signal generators: Jackson 640; Supreme 571; Precision E-200. V-O-M's: Jackson 642; Hickok 202; RCA Jr. Voltohmyst; RCP 662. Also Jackson 650A condenser tester; C-D BF-50 and C-D BN capacitor bridges, also panel mounting meters, all ranges. Chas. P. Courtney, 520 E. "C" St., Belleville, Ill.

WANTED—Triplett V-O-M or Weston. Also a good sig. generator. Wm. A. Fremlin, R.F.D. No. 1, Milford, Mich.

FOR SALE OR TRADE—Supreme No. 589 combined RF and audio signal generator, $55. Will buy for cash complete Rider's manuals, chanalyst, signalyst, volt-ohmyst, capacitor analyzer, Hallicrafter Sky Traveler. Henry Balabanow, 3814 N. Sheffield Ave., Chicago 13, Ill.

WANTED—Good used test eqpt. of late design for new shop. William W. Ulery, 301 E. Martin St., San Antonio, Texas.

WANTED—Sig. generator and vac. tube volt meter. Cash. R. L. White, 1748 Third Ave., Oakland 6, Calif.

URGENTLY NEEDED—Com. receiver or any portable commercial radio and test eqpt. Pvt. Lloyd C. Woodard, 534th Service Squadron, Kelly Field, Texas.

FOR SALE—Have goodly number of 1C5GT/C; 6L7G; 6L7; and 78 tubes to sell or trade at sacrifice for more popular tubes. C. K. Allen, 1700—7th Ave., Beaver Falls, Pa.

EQUIPMENT WANTED — Hickok No. 530 tube checker; Hickok No. 177 or 188 sig. generator; Solar CB 1-60 or Jackson 650 A capacitor analyzer. Ferd. Nessler, 1020 University Ave., Dubuque, Iowa.

WANTED—Super Skyrider SX-32. Good cash price. John Gil, 160—8th St., Passaic, N. J.

V-O-M WANTED—or V-O. Either factory-built or compl. factory assembled kit for either. Tech. Sgt. C. L. Hollman, Darnall General Hospital, Danville, Ky.

FOR SALE—No. M1534 power transformer 1200 V C. T. at 200 ma. 6.3V at 3A and 5V at 3A. Shure 5DB carbon mike; also one large and one med. size DB mike transformers 200 C.T. to single grid. Want 12" heavy duty PM speaker. Maxeiner's Radio Service, Okawville, Ill.

WANTED—First model Meissner 12-tube F.M. receiver with or without 6L6 audio stage. D. Hill, 45 7th Ave., New York 11, N. Y.

FOR SALE—Meissner 9-1000 push button remote control unit, $15. Also battery and electric type used radios; 1200 tubes (all types)—satisfaction guaranteed or money refunded; two master units wireless intercom system, $50. Will trade Colt 32 cal. automatic for radio tubes. Goodwin Radio Shop, Rankin, Ill.

WANTED — RCA signalyst or other sig. generator of good make, also RCA-Rider Sr. voltohmyst in good condition. Walter Schofield, 346 Oak Grove Ave., Fall River, Mass.

FOR SALE — New Astatic JT-30 xtal mike with cable, $10. Want one 807, RK39 or similar tube for cash. Bob Stofan, 332 Herrick Ave., Teaneck, N. J.

WANTED — RCA camera type receiving set. Describe fully. Wallace Wolfe, R. R. No. 3, Warsaw, Ind.

FOR SALE—Westinghouse O-15 DC Ma.; Weston O-5 DC voltmeter; Weston AC-DC O-6 amps.; Sterling O-15 DC Ma.; G-E O-8 DC amps.; Sterling O-3 AC voltmeter; 83 mercury rectifier; two 4 mfd. 1000 V. new condensers; Brandes headphones; 8" fan; AC noise filter; electric clock; Triplett 3332 battery oscillator. $25 takes all. S. J. Zuchora, 2748 Meade St., Detroit 12, Mich.

WANTED—Recording unit with play-back less amplifier, speaker, mike, etc. M. L. Birkett, 2415 E. 7th St., Tulsa, Okla.

FOR SALE — RCA 811, $3.50; 845, $10; Westinghouse 805, $13.50; Eimac 150TS, $25; Eimac 100TS, $13.50; DeForest 511, $10; RCA 204A, $35. All new. Used Sylvania 211C, $5; RCA 809's, $2.25; RCA 76 (isolantite base), 75c. Also Hoyt O-1 ma. movement 3½" meter with VOM scale mounted in Bud meter holder, $5; Hammarlund Comet Pro receiver rebuilt with metal tubes, compl. $35; RCA Jr. velocity mike, cradle mtd., No. 4035, $44; Astatic D104 crystal mike, $22.50, also various speakers. Write for list. Fred Craven, 2216 So. 7th St., Philadelphia 48, Pa.

WANTED—4 or 5-band coil assembly, also S. W. signal booster and 15" speaker to handle 20 to 25 watts, electro dynamic. Henry Ecklund, 290 E. Lawson St., St. Paul, Minn.

WANTED—Dual speed Green Flyer 110V. phono motor; Thordarson T15S91 output trans.; and T15C54 or T15C55 Thord. choke. Pfc. Thomas Slack, 33340576, Hq. & Plot. Co., 576 S.A.W. Bn., Drew Field, Tampa, Fla.

TUBES FOR SALE—5—024; 1A4P; 5—1A5GT; 1A6; 1B5 and other battery types. Write for list. Gerhardt's Radio, Defense Highway, Lanham, Md.

WANTED—Rider's manuals 7 to 12. Also want to have R.C.P. multitester meter repaired. Oliver L. Bessetti, 18 South St., Danielson, Conn.

WANTED—Superior or RCP tube tester with charts. H. R. Ringold, 132 N. Doheny Dr., Beverly Hills, Calif.

WANTED—RCA voltohmyst Jr. Gilbert Bers, 1352 Sheridan St., N. W., Washington, D. C.

FOR SALE—200 assorted radio tubes, no high or low volt or rectifier types available. Also some repair parts. Write for list. J. C. Thimijan, 715 N. 7th St., Lake City, Minn.

FOR SALE—Hallicrafters S20R com. radio, like new. Tunes 550 kc. to 44 mc. $50 cash F.O.B. Lewis C. Chapman, Rt. 1, Columbus, Miss.

WILL TRADE—printing eqpt. for radio test eqpt. Write for details. Roy B. Wanders, 3228 N. Osanam Ave., Chicago 34, Ill.

WANTED—Tube tester in good condition. R. M. Blomquist, Maplewood Station, Sulphur, La.

FOR SALE—Skybuddy receiver and two 552 Mallory vibrapacks, and one 551 vibrapack. Elmer E. Ash, 109 E. Woodruff, Port Washington, Wisc.

WANTED—New or used RCA Jr voltohmyst; also O-200 microampere and O-1 milliampere meters. Robert Hamilton, 5029 Penn St., Philadelphia 24, Pa.

WANTED—Late model portable tube tester. Gabe's Radio, 113 E. Walnut St., Green Bay, Wisc.

WANTED—Cash for Triplett 1200A V-O-M or other good make. I. C. Gutierre, 1019 N. Stanton St., El Paso, Texas.

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oscillator, the action comes from the negative slope of the static-characteristic curve which gives rise to the necessary negative resistance. Once the electrons leave the filament they travel on to one of the split-anode segments and do not oscillate in the inter-electrode space. Oscillations do not come from the travel time of the electrons, but rather from the fact that the electrons have a tendency to hit the plate of lower potential, a condition brought about by the strong magnetic field present.

In the transit-time magnetron, on the other hand, the oscillations are dependent on the time of flight of the electron from the filament to the plate and back again. Here the electrons that are most important remain in the inter-electrode space for a relatively long time, oscillating between the filament and plate. The path is usually complicated and any diagrams are, at best, only approximations. Fig. 7 is such a diagram. It is hard to say where the magnetron oscillator ends with the negative-resistence operating principle and switches over to the transit-time idea. The transition is not entirely distinct and the only generalization that can be made is to say that for very high frequencies, the transit-time oscillator should be used whereas for longer wavelengths, the negative-resistance magnetron is more efficient. The circuits remain the same in either case, the only change occurring in the operating conditions.

(To be continued)

Postwar Television

(Continued from page 46)

and the price of wheat in Russia today's news—let alone its heroic victories—so will television make the world's events visible to us—almost as soon as they happen. The education of our children, the dissemination of information of the new and proper methods of the raising and treatment of crops and livestock will be "televised" to all. Breeding methods, prices and discussion of agricultural problems will be broadcast—sound and sight—to all.

This unpleasant business of war has undoubtedly hastened television's debut. On the credit side of the last war are but few items; such progress would have been made with less loss of life and suffering, with great financial saving and better coordination under the civilizing influence of peace—but, nevertheless, it is true that the war hastened the general introduction of the airplane, tractor transportation, certain dye formulas and other inventions. It is not a civilized desire to hope for the war to hasten inventions (except for barbarious war profiteers) but, it still is a sad fact that the war does quicken the introduction of inventions; and military leaders realize the potentialities of television.

Photographers in planes may take pictures which may be almost imme-

diately televised back to headquarters. Enemy lines, retreats, advances, and other data may be flashed back to commanding officers.

As already mentioned, television has financial obstacles which it must overcome. The problem of sending clear, sharp images through space or by wire is a large one. Dr. Alfred N. Goldsmith, a famous engineer, has studied the possible costs of television entertainment production. As films may be used to a large extent, motion-picture costs were compared with radio costs. It costs about $120,000 for an hour of movie entertainment. It costs about $2,500 for an hour's fun and song by radio. Obviously, television cannot proceed at the radio rate of consumption and at the film cost of production!

No matter what plan is evolved (there are several possible ones) such as the continuation of the present system of programs sponsored by advertisers; or programs supported by taxes on receiving sets (which is done in England and Canada); or programs supported wholly or in part by the Government; or any combination of these methods, the cost will be higher than radio costs.

The solution to this particular financial problem seems to lie in finding cheaper program material—such as cheaper methods of producing pictures, use of radio studios, stage and vaudeville entertainment, and educational programs. It is also possible that television entertainment may not be continuous—as is radio. It may be just offered at certain set periods—such as a few hours nightly, as in the theater.

The other major financial difficulties are the cost of building stations, transmitting programs, of relay stations, wire systems, and last, but never least, the cost to us—the well-known ultimate consumer.

If our large radio companies believe that television will be the future of their business, they will find some way to pay for the cost of equipping and maintaining stations. The other cost, a possible selling price of $250 or so, for receiving sets is a horse of a different color. It is a serious question as to how many of us could afford $250 for a set—even if purchased on the installment plan. Perhaps that is possible during wartime conditions —but who can tell what conditions will be like after the war? In any case, if television sets were manufactured in large quantities, it is entirely possible that sets could sell at a much lower figure than $250. This, of course, is something to be worked out by the manufacturers.

Television, of course, will be primarily a source of entertainment—just as the radio and movies. But it will also be an educational medium of considerable importance. Obviously, it will aid in the spread of farm and general information. It will also help the teacher and the student. A professor at the University of Iowa has demonstrated conclusively that tele-

vision can be utilized in the classroom. Lectures on such subjects as astronomy, botany, art and shorthand were supplemented with television pictures of material pertaining to these lectures. The class in astronomy saw pictures of constellations "televised" to a screen in the classroom; shorthand students saw the hood and line symbols televised.

We can only guess what the postwar world will bring us in the way of television, but one thing we can be sure of—scientists are even now working to bring that achievement to a reality.

—30—

Practical Radio Course
(*Continued from page* 48)

it. The so-called *voice-coil impedance* specified is usually that impedance which the speaker shows at some middle frequency (400 or 1000 cycles), or else it may be an average of the impedance variation over some middle range of frequencies. Accordingly, no speaker can be "matched" to an amplifier at all frequencies. Moreover, the speaker impedance usually increases abruptly and appreciably at the several resonance points in its response range. If an amplifier has a high output plate resistance, as will be the case if pentode or beam tubes without feedback are used in the output, the variation of plate circuit loading due to either of these causes will result in distorted response. However, with inverse feedback greatly reducing the value of the plate resistance, these variations can be made to have little or no effect on the amplification obtained.

In addition, it often becomes necessary in the field, to mismatch a speaker load to an amplifier, because the proper impedance taps are not available on the amplifier. A feedback amplifier can tolerate appreciable mismatching of this kind without difficulty.

In a multiple-speaker P-A system, if loudspeakers are cut in or out of the circuit the impedance reflected to the primary of the output transformer will change, causing variations in the voltage developed across it. For example, if two 8-ohm voice coils are connected in parallel across a 4-ohm output tap, a certain impedance will be reflected to the primary. Now, if one of the loudspeakers is removed from the circuit, the effective impedance of the primary will be doubled, and a higher signal voltage will be developed across it. Consequently, a greater voltage will be fed back through the inverse feedback circuit and the gain will be reduced, tending to keep the power output of the amplifier at a constant level. This property of inverse feedback amplifiers greatly facilitates loudspeaker switching problems and makes the use of artificial loads unnecessary provided the load is not permitted to vary over too wide

a range. That is, this type of compensation should not be expected to handle such extreme situations as that of a 4-ohm voice coil connected across a 500-ohm output for example, but within reasonable limits of load variation it will prove quite satisfactory. It is perfectly feasible to design a feedback amplifier so that a mismatch of 2:1 in the speaker load makes no apparent difference in the performance. This ability of feedback amplifiers to provide such self-regulating action of output level where the output load varies over such a wide range is greatly appreciated by P-A men in the field.

(To be continued)

Panoramic Reception

(Continued from page 37)

the signal going through this amplifier at any instant is the one which differs from the radio frequency oscillator frequency at that instant by 100 kc. Thus, as the oscillator frequency changes from 405 to 305 kc., frequencies from 505 to 405 kc. in the special I-F amplifier will be passed in succession through the panoramic 100-kc. intermediate-frequency amplifier. The output of this amplifier is rectified in the panoramic second detector, amplified once more and applied to the vertical deflection plates of the cathode-ray tube.

The cathode-ray tube operates by means of a beam of fast-moving electrons which strike a fluorescent screen in the front of the tube. When the tube is at rest, the electron beam appears as a single bright spot on the screen, but under the influence of external voltages applied to the tube's horizontal and vertical deflection plates, this spot is moved from side to side and up and down. When the movement of the beam is rapid enough and repeats itself often enough, it appears to be a continuous line or pattern on the screen.

In the Model S-35 Panoramic Adapter the horizontal movement of the electron beam is controlled by a sawtooth oscillator. Fig. 4A shows the output voltage of such an oscillator. Under the influence of this voltage the electron beam moves from left to right across the face of the tube and returns almost instantly to its starting position. The frequency of the sawtooth oscillator is approximately 20 cycles-per-second and at that speed the bright spot becomes a luminous horizontal line. The length of the line is adjusted by varying the voltage output of the sawtooth osc.

In addition to furnishing the horizontal sweep voltage, the sawtooth oscillator also controls the reactance modulator which varies the frequency of the panoramic radio-frequency oscillator. This circuit is so arranged that at minimum voltage from the sawtooth oscillator the frequency of the variable radio-frequency oscillator is a maximum and at maximum volt-

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age it is a minimum. The amount of frequency variation can be adjusted by controlling the degree of reactance modulation.

Assume that the communications receiver is tuned to a signal on 5,000 kc. This signal will be amplified in the radio-frequency stages and will combine in the receiver first detector with the 5,455 kc. signal from the high-frequency oscillator. The important frequencies present in the output of the first detector will be 5,000 kc., 5,455 kc., 10,455 kc., and 455 kc. This latter signal will pass through the receiver intermediate-frequency amplifier and be heard in the speaker. It will also go to the special I-F amplifier of the panoramic adapter and be passed through to the first detector with relatively little gain. (See Fig. 3.)

The frequency of the panoramic variable radio-frequency oscillator is constantly changing from 405 to 305 kc. as the sawtooth oscillator goes from minimum to maximum and the horizontal sweep on the cathode-ray tube swings from left to right. When the variable radio-frequency oscillator passes through 355 kc., the output of the panoramic first detector will contain 455 kc., 355 kc., 810 kc., and 100 kc. This last frequency will pass through the sharply tuned 100-kc. panoramic intermediate-frequency amplifier, second detector, and video frequency amplifier and will appear as a narrow inverted "v" at the center of the screen, the horizontal sweep circuit having reached that point at the same instant that the variable radio-frequency oscillator reached 355 kc. (Note: Do not confuse the video frequency amplifier in the panoramic adapter with a television video amplifier which must pass a band of frequencies 4 to 5 mc. in width. In this case it is only necessary to pass a band of approximately 2 kc.)

At the same time that the 5000 kc. signal is being received many other signals are present in the input circuit. Assume another signal on 4950 kc. It passes through the radio frequency stages into the receiver first detector but at a much lower level as it is 50 kc. off resonance. It also combines with the output of the 5455-kc. oscillator to produce frequencies in the receiver first detector output of 4950 kc., 5455 kc., 10,405 kc., and 505 kc. None of these frequencies will pass through the intermediate frequency amplifier of the communications receiver but the 505 kc. signal will go through the special I-F amplifier of the panoramic adapter.

Referring to Fig. 3 it will be seen that this signal will be amplified to a much greater extent than the 5000-kc. signal (455 kc. at input of panoramic adapter), thus compensating for the loss of gain caused by its being 50 kc. off resonance in the receiver radio-frequency stages. This second signal appearing at 505 kc. in the first detector of the panoramic adapter will pass through the 100-kc.

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It's a long way from fireside to firing line. Especially long for a radio set. For when you take this coddled precision instrument away from the peace and calm of a living room and stick it in a mobile unit at the front, you're really putting it "on the spot." Jolts, jars, concussions and extremes of temperature are the common lot of radio and electronic equipment in military service.

Fortunately, this transition was not as abrupt as it might have been, for Delco Radio technicians had tackled and solved similar problems in making automobile radios practicable. Vibration and shock . . . heat and humidity variations . . . electrical interference . . . shaking and bumping—all these obstacles were overcome one by one through the ceaseless experimentation and research of radio scientists.

With the conquest of the foes of *radio in transit* came far greater benefits than better entertainment. Years ahead of the second World War, the Delco Radio Division had solved many of the problems which inter-vehicular military radio would face. Years ahead of time, the "spirit of perfectionism" had prepared vehicular radio for its vital role at the battlefront.

Let's All Back The Attack!

BUY WAR BONDS

Delco Radio

DIVISION OF

GENERAL MOTORS

intermediate-frequency amplifier when the variable radio-frequency oscillator reaches 405 kc. As this occurs at the minimum point of the sawtooth oscillator output, the signal appears at the left end of the base line on the screen. Fig. 4B shows the screen with the two signals described above.

By similar reasoning it will be seen that any signal within the 100-kc. band width of the panoramic special I-F amplifier will pass through the adapter at the correct time to appear on the screen in its proper relationship to other signals.

The band of frequencies covered may be reduced by decreasing the action of the reactance modulator and if this is done while holding the amplitude of the cathode-ray tube's horizontal sweep voltage constant the signals in the center of the screen will spread and those on the edges will move outward and disappear. When adjusted for maximum band width, the signals are tall and narrow, amplitude-modulated signals fluctuating up and down and telegraph signals appearing and disappearing in synchronism with the keying. Frequency-modulated signals remain at a constant height but appear to change in width as side bands appear and disappear during modulation. As the width of the band being observed is decreased, the signals spread out and their individual characteristics may be more easily observed. If the action of the reactance modulator is decreased to zero so that only one station is visible on the screen, a simple wave-envelope pattern will appear.

The design of the automatic volume-control circuit in this equipment presented an interesting problem. An ordinary A.V.C. circuit is designed with a comparatively large time constant so that it will compensate for fading or for varying levels of signal strength as the receiver is tuned to different stations, but will not respond fast enough to suppress audio-frequency modulation. For example, if the lowest audio frequency to be received is 45 cycles per second, the time constant of the A.V.C. circuit must be .022 seconds or more.

A brief analysis of the scanning action of the cathode-ray tube will demonstrate the *inability* of an ordinary automatic volume control to meet the requirements of this receiver. The horizontal sweep covers the screen 20 times per second which means that at maximum band width, it scans 2000 kc. every second or moves 10 kc. in .005 seconds. Assume that a comparatively strong signal is present at some point in the band under observation and that a weak signal is located 10 kc. higher. As the 100-kc. amplifier in the panoramic adapter has a maximum band width of 2 kc., there will be no difficulty in separating the two signals but, if a standard A.V.C. circuit is used, the strong signal will reduce the gain and .005 seconds later when the sweep passes the weak signal, the gain will

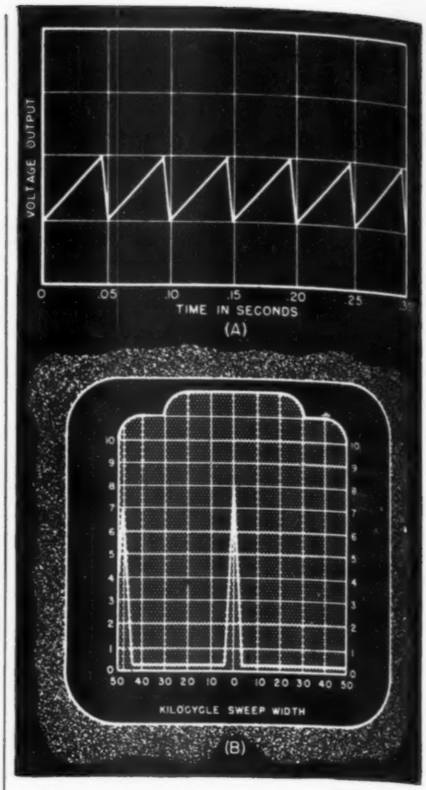

Fig. 4. (A) Output voltage graph of sawtooth oscillator. (B) Screen of cathode-ray tube showing two signals.

still be reduced and no signal will appear.

The solution lay in designing a double A.V.C. system. A.V.C. voltage is taken from the diode second-detector of the panoramic adapter in the usual manner but two filter circuits are provided. The first A.V.C. filter has a time constant of .022 seconds, which enables it to compensate for all variations of carrier level of more than .022 seconds duration. This circuit is connected to the panoramic special I-F amplifier and controls the over-all gain. The A.V.C. voltage is also applied to another filter with a time constant of 235 micro-seconds which is connected to the 100-kc. intermediate-frequency amplifier. With the panoramic adapter adjusted for maximum frequency coverage, the electron beam will scan a band of only 470 cycles in that period of time and it is evident that this second A.V.C. can easily adjust the amplitude of signals separated as little as 2 kc., the band width of the amplifier.

The extremely fast action of the second A.V.C. filter made it necessary to provide a panel operated control for the degree of A.V.C. action. As this circuit can adjust itself to changes of carrier level occurring only 235 micro-seconds apart it will obviously suppress all modulation frequencies below 4,255 cycles:

$$f = \frac{1}{T} = \frac{1}{235 \times 10^{-6}} = 4{,}255+$$

When amplitude modulation or other similar phenomena are being observed, the A.V.C. action can be reduced to the desired level by means

of Resistor R_1 in the schematic diagram.

Many practical applications of panoramic reception will readily occur to the experienced radio man. Its value in monitoring the various frequency bands is obvious and becomes even more apparent when it is known that weak signals that could easily be missed in the noise and "static" of normal loudspeaker reception are plainly visible on the screen. When such equipment is once more available, the marine services, airlines, amateurs and all who have occasion to look for signals over a wide range of frequencies will find Hallicrafters Panoramic Adapter a revolutionary improvement in their work.

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Jungle Broadcast
(*Continued from page* 39)

the Buna campaign who directs jungle training for Mobile Force, whipped out his pistol, pointed it in the air near the mike, and pulled the trigger. Weathers still hopes it sounded like a pole charge destroying a Jap-type pillbox.

The announcer-sergeant had another, but non-technical, problem. His first speaker was Lieutenant General George H. Brett, head of the Caribbean Defense command, and the second was Major General E. F. Harding, Mobile Force commander, and a veteran of the Buna campaign. Both have reputations as genial generals, but the average soldier may be in the army for many months without ever seeing as much as a brigadier. After the brief experience with his prominent guests, however, handling ordinary captains and lieutenants held no worries and Weathers lost the only slight case of jitters he has had around a mike in years.

Sergeant Bras had nothing to contend with higher than a lieutenant colonel who led a group of swimmers through a wall of blazing gasoline, and a nautical private who insisted on putting "hello, mom" into the script.

However, Bras and Sgt. George Odom, a KSFO (San Francisco) man before the war, were "sweating out" another problem. It was their mike. Five minutes before they were to go on the air, Bras and Odom went through a final checkup. Odom claims that what came out was the most silent silence he has ever heard. They made a quick check of the connections, found everything in order, tried again, and still got no sound. More from disgust than from any hope of success, Chuck jiggled the microphone, and the final test was made. The "one, two, three, four" came through; everything was all right again, and, except for wondering if the mike would go out sometime during the remaining 10 minutes, there was no "hitch" in the entire 75-mile-plus setup.

Bras' soft voice told its story: jungle swimmers wearing full equipment swimming across the river—through fire—supporting troops going over in boats, ammunition and mortar fire with its soldier-director screaming "On the way!! On the way!!!"

". . . the Army Hour returns you from the jungles of Panama to the United States in New York;" the Q line answered "Thanks, Panama, that was swell," and it made it all worth it.

But, as Odom, Bras, Weathers, Wyberg and Braymes left the Mobile Force training area, they mused over a line which Private Bill Osborne of Hinton, W. Va., had said when called to the Mike: "I used to think that the jungle was something that nobody but Tarzan would go into, but I know different now."

"Tarzan was smart," Bras explained dryly. "He traveled in the trees."

They left, speculating on what Lord Greystoke would have done about hauling all that radio equipment back where they got it.

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Mine Locators

(Continued from page 34)

electrical fields is disturbed and the instrument is useless.

The initial orders for the detector were placed with various firms in Britain's radio manufacturing trade. The creation and adjustment of an electrical field is not a difficult job in theory. Production of the equipment for use in the field is another story.

All sorts of difficulties that the layman would not ordinarily anticipate were encountered. Take, for example, the wax that holds the coils in position. The War Office specified that the equipment must be for use in both tropical and arctic ranges of temperature. The trouble about wax with a high melting point is that under conditions of severe frost it cracks and shrinks. If the wax moves even so much as one-thousandth of an inch the coils come out of adjustment and the detector is useless. Contrariwise, a wax which will not crack in severe cold has a low melting point and will melt in the tropics.

The heaviest and most critical period in the evolution and production of the electrical mine detector was in June of 1942 for most of the detectors which had been stored in reserve in the Middle East were lost when Tobruk fell. They had to be replaced as quickly as possible. And replaced they were. But the reorganization involved in drastically stepping-up the output to make good the losses was considerable.

Yet, largely by the unstinting efforts of the girls who assemble the weapons, the deficit was made good.

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